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Frontier Kluwer Academic Publisher Editorial

Resource Management in MPSoCs - Is our software ready for it?

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Multiprocessor Systems on Chips (MPSoCs) represent the future of embedded platforms. Their use is increasingly more widespread in many embedded applications ranging from multimedia to biological processing [1]. The design of system components and their interconnection has seen a rapid evolution on several fronts, to satisfy application requirements while ensuring flexibility. Currently, two main directions can be identified that lead to commercial products: master-slave architectures such as Cradle, Nomadik and homogeneous architectures like ARM MPCORE. In the future, mixed approaches (i.e. a cluster of master-slaves nodes) are envisioned.

Due to the increasing complexity of these processing platforms, there is a large quantity and variety of resources that the software running on top of them has to manage. This may become a critical issue for embedded application developers, because resource allocation may strongly affect performance, energy efficiency and reliability. As a consequence, from one side there is need to efficiently exploit system resources, and, on the other side, fast and easy development of applications is a critical issue for embedded applications. In other words, the architectural organization of future embedded systems will become more and more similar to *high performance computing* (HPC) systems from a memory hierarchy perspective (with the *Non Uniform Memory Access* – NUMA – model) and to distributed systems, such as *computer clusters* (CC) for the interconnection mechanisms (e.g., *Networks on Chip*). However, the programming paradigm developed in the HPC and CC fields cannot be exported as they are in the embedded context. As such, the lack of suitable programming tools might represent a bottleneck for the widespread diffusion of MPSoCs.

To avoid this risk, the main obstacle to be overcome is the gap between the programmer's view and the embedded architect view. Namely it is the huge amount of information not directly related to code development that a programmer needs to handle for the efficient mapping of an application. This information is related both to architectural issues (memory architecture, communication infrastructure, etc.) and to resource management issues (with task voltage/frequency allocation for performance, power, thermal, reliability management). In this

context, the challenge is now to develop a convenient but efficient programming model/environment for the software developer that is able to fill the gap between programmer's view and lower-level architectural details through an efficient resource management methodology.

To achieve this target a new software abstraction layer is needed. Such a layer must be designed with the following purposes: i) provide to the application developer with a programming model aimed at rapid application development, while hiding as much as possible lower-level architectural details; ii) support the transparent integration of *dynamic resource management* (DRM) policies to efficiently handle all the architectural resource management issues that are now hidden to the application developer.

The whole software infrastructure ranging from operating system, middleware to compilers, libraries and *application programming interfaces* (APIs) must be designed for this purpose. Currently there are efforts made in this direction in the context of single processor architectures. *OpenMAX* is an example of integration layer, whose purpose is to interface multimedia frameworks like *Gstreamer*, multimedia components (like audio and video codecs) and low level hardware (CPUs and DSPs). While *Gstreamer* provides programmers with an easy way to develop multimedia applications, *OpenMAX* takes care of mapping resources, such as memory buffers and communication channels, to the low level hardware. However, there is still lack of efficient application of this support in the field of multiprocessor systems. For example, due to the non-uniform memory access organization of modern MPSoCs, memory buffer allocation is a challenging task, also considering variable and dynamic application requirements. Moreover, since multimedia applications consist often of several tasks, their mapping into processing elements has to be performed in an efficient way to exploit the available computational power and to reduce energy consumption of the platform.

Now, what are resources in MPSoCs? Core processors, memories, input-output components are examples of resources. As such, the problem of dynamic resource allocation consists in mapping these resources to tasks depending on runtime workload conditions. In general the problem of mapping is spatial and temporal. For example, scheduling tasks in a multi-core system involves temporal and spatial allocation of tasks into processor cores. Task scheduling is a complex and critical problem in multiprocessor systems. The target is to balance the workload among processing units to minimize some metric such as overall execution time, power or even temperature. However, workload variability requires frequent updates in the task allocation configuration, so that task migration has to be used to move tasks among cores. The overhead associated with this operation has to be carefully considered.

Also system power can be considered as a resource to be allocated. In this way, frequency and voltage setting can be considered as an allocation problem too. They have to be selected in such a way to match the requirements of the running application while reducing the amount of power drawn by the system. Workload estimation techniques, usually based on past execution history, have to be used to set the frequency in a proper way. Sudden workload variations may cause adaptation mismatches that are paid either as a waste of power or performance degradation.

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Focusing on processor cores, runtime task allocation and voltage selection strategies have been shown to be promising techniques to achieve load balancing, power minimization, temperature balancing and reliability improvement.

The need for run-time resource management stems from the inherent limitations of static approaches that are often unpractical, because they require extensive off-line characterization (through simulation or emulation) and they cannot handle run-time requirements such as performance, power, reliability, thermal constraints that may vary dynamically.

Moreover, although an application could be pre-characterized and could be able to provide run time information (i.e. actual required throughput) to the low-level software support, resource management needs to be performed also when no information about the application are provided to the lower level.

The ability to dynamically move computation among processors according to the run-time application/environment issues is essential for an efficient dynamic resource management. Task migration is one of the proposed solutions to achieve dynamic resource management in high performance computing platforms, such as high-end multiprocessors and computer clusters. *Mosix* is a well known load-balancing support for CC implemented at the kernel level that moves tasks in a fully transparent way. In the embedded system context, task migration support has to trade-off transparency with efficiency and lightweight implementation.

On the implementation side, task migration support depends on the architectural model and on the communication paradigm. Modern MPSoC designs are architecturally similar to computer clusters. The acronym "*Clusters on a Chip*" indicates the ongoing direction of platform design, where computing nodes can access both private and shared memories (following the NUMA model) and they are connected through hierarchical busses or Networks on Chips.

In this architectural context, task migration involves task memory content transfer. As such, care must be taken to minimize the overheads that could impact performance and predictability. Techniques developed in computer clusters cannot be reused as they are. For this reason, there is the need of developing an efficient strategy in the context of embedded loosely-coupled MPSoC systems.

Once tasks have been allocated to processors, a suitable voltage/frequency selection must be performed. A dynamic resource manager should make the appropriate decisions based upon on-line information. Several techniques have been developed in the past. In the context of streaming applications with throughput requirements, feedback strategies have been proposed that are suitable for MPSoCs. Feedback-based techniques are more efficient and proactive with respect to local strategies [2][3].

In summary, a suitable software technology able to hide architectural/resource management issues to a software developer has to provide the following services: i) a clear and easy-to-use programming model and a low level set of services for concurrent programming, such as task

migration, communication and synchronization; ii) the support for the integration of efficient dynamic resource management policies. DRM must be able to efficiently manage resources also in the common case where there is no application pre-characterization and no information about run-time application requirements is provided.

To achieve this goal, there is still a considerable amount of work and research to be done by software engineers who are also responsible for providing feedback to hardware architects to drive their choices.

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Frontier Visionary Interview Column

Interview with Don Peppers

Frontier Journal (FJ) Typically what customers want is maximum benefits on products and/or services with zero cost; while vendors, as business as a for-profit-organization, attempt to generate maximum profits with minimum operation cost, how to resolve the inherent conflicts between vendors and customers?

Don Peppers (DP): This is looking at the customer-vendor relationship from the wrong perspective. In older times, when manufacturing and information technologies were incapable of any form of variability, then yes, marketers made things and customers either took them or they didn't. It was a zero-sum game in many respects, with whatever dollars the customer took off the price coming directly out of the profits of the vendor. But because of new technologies, vendors and customers can interact with each other more cost-efficiently, and manufacturing and service delivery can be more tailored to individual customer needs.

So the type of customer-vendor relationship we see much more often today is one that is based on trust and mutual benefit. My customer interacts with me and tells me what he wants, possibly online, or perhaps by phone, or by communicating with a sales person who has access to a CRM-enabled sales force automation tool. I then change some aspect of my service or product to meet the customer's need, and we interact again. I ask him: "Did you like it that way? OK, next time we can do it like this, or like this..." The point is, with every interaction the customer becomes more loyal to me, because the interaction develops a context that is difficult for him to reproduce somewhere else. The customer would first have to teach another vendor everything he's already taught me. So a relationship built on interaction and just a bit of customization can create an immense incentive for a customer to remain loyal, and to work through any problems he has with the vendor in order to continue the convenience of not having to completely re-specify his preferred type of service or product.

An easy example frequently used is Amazon.com. If you are a regular Amazon customer (as I am), then when you see a book you like you just click on it and it comes automatically to your house. Amazon already has your address and your credit card number, so it's very easy to order the book. For any given book, you will almost certainly find it cheaper somewhere if you look hard enough. But that would mean re-entering all the information, and if you feel that Amazon's "recommendation" service has any value at all, then buying the book from some other site will erode its effectiveness.

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FJ : Precision-based Marketing such as 1-to-1 Marketing with customization and personalization in mind gains its momentum nowadays as prospects and customers have much more choices than that of in old days. How can we reduce the cost overhead introduced by 1-to-1 Marketing as opposed to traditional marketing?

DP: If you base your service of many different customers with different needs on the principle of pre-manufacturing all the possible products and choices they will want, then you will indeed go bankrupt. And you deserve to.

We do not advocate this foolish idea. What we suggest is that you should apply the principles of mass customization. Modularize your production or service delivery process, in ways that allow you to add more and more modules. Then, it is the digital combination of those modules that creates thousands - or millions - of choices.

We know a credit card company that offers its card in more than 2 million varieties. These are all the possible results of combining just five different modules. Each module (interest rate, annual fee, sport team affiliation, reward structure, etc) has a dozen or more possible "settings." When you multiply the possibilities together, the card can be delivered to any particular customer in more than 2 million ways. But actually, the only thing the card company is doing is specifying a few dozen options. Then the technology of interaction and process management digitally combines different options into the final card product.

In most such situations, the actual cost of delivering finished goods to the customer will be less - sometimes very much less - than standard manufacturing. For instance, HP no longer makes separate printers with their own individual power supplies for each different region of the world, for instance. Instead, the company makes a single printer engine that can accommodate a number of different power supplies, then it ships these engines to their destination where the final power supplies are installed. HP did this to save costs. The increased cost of a "standardized" printer engine is more than offset by the reduced inventory costs and wastage of all the separately manufactured machines that could not be transferred from one region to another.

The same kinds of cost savings apply to service delivery. St. George Bank in Australia has cash machines that remember customer requests. So you put your PIN code in and the machine might ask you "would you like your 'regular' \$100 cash, no receipt?" Just push "yes" and you are finished. No need to step through the series of questions - deposit, withdrawal or transfer? - checking or savings or money market? - receipt or no receipt? From the customer's standpoint it is much more convenient to be served individually like this. But from the bank's standpoint it's less costly, too, because each ATM can serve more people in the same amount of time.

FJ: To meet customers' expectation is any business' prime goal, since it is customers who offer you the life blood. How to help customers to set their realistic expectation instead of irrational one? When and how shall we say NO to which kinds of customers?

DP: Knowing which customers you lose money on - and the ones you will probably never make money on - is a critical part of any customer strategy. After all, the essence of "strategy" is not what you decide to do, but what you decide you won't do.

Sometimes, because of the structure of your industry or your distribution network, or simply because of the type of market you're dealing with, you will have to cope with very powerful customers - customers who have a great deal of negotiating leverage in their relationship with you. Customers like this can demand and get highly favorable terms, in the form of lower prices, better services, priority delivery, and so forth. Occasionally such customers are so powerful that they may all but require you to lose money just to serve them.

In retailing, the giant mega-stores and category killers, such as Wal-Mart and Toys-R-Us, are very tough customers. In the high-tech field, companies that manufacture components in mature markets, like microchips, must sell to tough customers like Dell, or Hewlett-Packard. In the automotive category, almost all of the manufacturers are large, difficult to deal with, and obsessively concerned with price.

It's important to keep your perspective when you must serve customers who are "oppressive" but still necessary. In the first place, you can only make rational decisions with respect to such relationships if you actually do a good job of tracking your customers' actual and potential values across your entire customer base. This means not just annual customer profitability, but some forecast of customer lifetime value as well, along with an estimate of growth potential - for all your customers, not just the largest, most powerful ones.

FJ: What is your perspective on innovation on Customer Relationship Management nowadays?

DP: You could make a strong argument that innovation has been the single most important driver of business success since before the assembly line, yet it has just recently become one of the hottest buzzwords in the business world, and nowhere more so than in the marketing discipline. Business observers seem to be paying more attention to innovation today partly because the hottest companies are truly innovative (think Apple, Tesco, Google, Zara, Intuit, Nokia, or GE, for example). But in addition, it's now clear that innovation is the only way a company can have any hope of meeting the relentless demand for financial growth and profit that characterizes today's increasingly fast-paced information economy.

The marketing function is smack dab in the middle of the innovation issue because customers have a great deal to do with it, and CRM now puts companies in closer touch with their customers than ever before. For any innovation to contribute to a firm's economic success, it must address a customer need. And customers, who wear the same type of product blinders as businesses do, aren't always very good at recognizing or explaining their unmet needs. Xerox photocopying met a tepid response from secretarial personnel who thought carbon paper was pretty good, thank you very much. IBM missed the first wave of the PC revolution because its mainframe customers (mostly IT department heads at large firms) saw no need for them, since the mainframes were so capable. Henry Ford famously remarked that "If I had listened to what

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people said they wanted, I would have designed a faster horse." Nevertheless, no business innovation can succeed unless it meets a customer need on some level, and truly creative innovations often meet needs that customers don't even realize they have until they are confronted with the innovation itself (think about the Worldwide Web, ATMs, cell phones, disposable diapers, or car navigation systems).

But actually, customers play an even more important role in marketing innovation - a role that goes beyond consuming new products and services. In my opinion, a firm's general attitude toward its customers is strongly linked to its inclination and ability to innovate at all. Research has shown that innovative organizations tend to have vibrant, energetic, and purposeful employee cultures. An IBM survey in 2005 asked 750 global CEOs where their innovative ideas came from. Forty-one percent said employees, 36% said customers, and just 14% said traditional R&D. (Booz, Allen studied a number of companies across different industries and found no correlation at all between R&D spending and successful innovation!)

Successful marketing innovation occurs when the employees of a firm try to solve problems or remove obstacles related to their purpose, as an organization. In a purposeful company the employees have a "sense of mission" that goes beyond simple profit or shareholder value. Employees in such an organization are eager to break down walls and overcome barriers when necessary to accomplish the mission. They're not just out to make money. They want to change the world. Innovation is simply the most direct means to that end, and making money is a happy side effect.

Consider: If your mission is to sell a previously defined set of products, then your employees will have difficulty removing their product blinders, and the culture will cause them to shun innovative ideas. But if your employee culture encourages people to constantly look for ways to increase the value they can deliver to customers, then your firm will be more receptive to innovative ideas designed to achieve that goal, even when those ideas might create a business that disrupts or stands completely outside of the current one.

FJ: We all understand that as business, we should always balance between the short term interest and long term interest when serving customers, as you call it for the sake of the Return of Customer as opposed to that of ROI. Now how to strike the balance between the short term interest and long term interest in general?

DP: Even if you have no hope of trying to understand how your current actions change the lifetime values of your customers, you can still base your business on earning the trust of customers, and being willing to give up short-term profit when necessary to protect the interest of a customer. Simply creating a company that customers and prospective customers feel will always "do the right thing" by them will set your firm on the path to balancing short-term and long-term. ROC is simply the metric that helps to quantify the actual financial benefit of this path.

Frontier Visionary Interview Column

Interview with Prof. Thomas F. Cooley

Frontier Journal (FJ) According to your observation, how much impact could education make on a person's fortune?

Prof. Thomas F. Cooley (TC): An enormous impact. Success is about luck and education. You can't control luck, but education, and especially, the right kind of education, is an investment that always pays dividends.

FJ: Are you a supporter of Keynes or Friedman?

TC: Keynes and Friedman are the two greatest economists of the 20th century, but neither really describes the economy of the 21st century.

FJ: Among the following best sellers on business: Build to Last/From Good to Great, Competitive Strategy/Competitive Advantage, Inside the Tornado/Across the the Chasm/Dealing with Darwin, Blue Ocean Strategy, The Long Tail, what is your most favorite book, and why?

TC: I found The Long Tail creative and thoughtful. One of my recent favorite bestsellers on business is Ron Chernow magnificent biography of Alexander Hamilton. Here is a man who had the vision, the energy, the enterprise and the immense erudition to lay the groundwork of the most powerful economy in the world.

FJ: What is the essence of management?

TC: In a sentence, I would describe the essence of management as understanding what it means to motivate people.

FJ: One one hand, there are quite a few highly successful businessmen who never went to business schools or received related education, such as Bill Gates, Steve Jobs, Larry Ellison, Jack Welch, Jerry Yang, Larry Page among others; on the other hand, there are equally quite a few highly successful businessmen who were trained at business schools or received related education, such as Sam Walton, Warren Buffet, Lou Gerstner among others. What is your perspective on the role of business education such as MBA training on shaping the future of our next generation business leaders?

TC: The first group you describe are innovators and entrepreneurs. The second group are masters at building, managing and changing organizations. Any great innovator will need a Sam Walton organizational genius to develop his idea to his maximum potential.

FJ: In the summer of 2000, I bought a book titled The Ten Day MBA, and I am still keeping the book at my office as a constant referrence. What is the esence of MBA education?

TC: The essence of MBA education is to teach students to think about business broadly--as a social, ethical, historical set of institutions, and to ensure that students have the analytical and intellectual training to articulate problems arising from new circumstances and find ways of preparing their organizations to meet and triumph over those challenges.

FJ: For most businessmen, who are very tight on bandwidths, even short-term based Executive MBA program is considered a luxury to them. How business schools can help those busy businessmen to fulfill their dreams of receiving formal (or semi-formal) business education without significantly interrupting their current business practice?

TC: The Stern School of Business has a broad portfolio of part-time and full-time programs that are designed to meet the needs of working professionals at different stages of their careers. But the education and the quality of the education is the same rigorous and demanding intellectual experience.

FJ: A typical MBA curriculum may consists of the following subjects, inlcuing but not limited to: Finance, Accounting, Operations (Execution), Micro/Macro Economics, Strategy, Organization Behavior, Quantitative Analysis, Leadership, Marketing, Ethics and Communication. Among them, Strategy, Organization, Leadership, and Execution belong to the essence of business, what is your perspective on how the above four components shall interact with each other to build a successful business?

TC: People have different interests and strengths and they bring them to bear on their business ventures. A successful business will require all of the elements you mention above. A good leader will have the ability to manage the organization so that it is successful.

FJ: As a leading business school, what is Stern's branding strategy, and how does it execute to implement the strategy?

TC: The Stern School believes strongly in the importance of a strong faculty and a research based institution. We train our students, not for their first job, but for a career lasting three or four decades, during which the social, political, and business environment may well change in ways that we cannot imagine today. What equips today's student to be a leader in the future is the ability to think broadly and effectively, to articulate the problems, to motivate employees, to develop smart and effective strategies, and to implement them. We also believe that business does not occur in a vacuum. Indeed, business is perhaps the great universal social institution of

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our time. Because of the importance of the role of business as a whole, we train our students to think about the social and ethical impact of their business decisions.

FJ: As a leading business school, what is the SWOT of Stern?

TC: Like every business school we are subject to the vagaries of the business cycle. Our strength is our faculty and the knowledge creation that takes place at the Stern School every day.

FJ: From an leading economist's perspective, what are the biggest challenges ahead for Macroeconomics and Microeconomics respectively?

TC: The major economic challenge of the 21st century will be to continue on the path of wealth creation that characterized the latter part of the 20th Century, but to ensure that all members of the global society benefit from that growth. Lifting poor nations out of poverty will require opening markets, enlightened public policy, and leadership by the wealthy nations of the world.

FJ: What is your business advice for those who are running their bootstrapping startups?

TC: Don't be afraid to fail. Successful entrepreneurs understand what it means to take risks and that's one of the reasons that they succeed.

Viewpoints from Editor-in-Chief

DesignCon III - The Challenges to the Widening Design Productivity Gap

Except the IEEE Solid State Conference, which is more academic oriented, DesignCon may be the largest annual gatherings for those designers, managers and executives in semiconductor and system industries. Last year, before we headed for Silicon Valley to exhibit at DesignCon 06, I made a suggestion to one of IEC staffs, who was in charge of DesignCon marketing, that was they should combine DesignCon, DesignCon East and DesignCon Euro all together, since it does not make any sense for a company to attend 3 similar trade shows in a single year, and DesignCon should also recruit EDA companies, since traditionally EDA companies are more aggressive on trade show based marketing as opposed to those semiconductor and system companies, one example is the annual DAC fathering, the number of exhibitors at DAC has been soaring during past several years, as DAC start to lure semiconductor and systems companies other than traditional targets, EDA companies.

I received the DesignCon 07 program guide this afternoon, while at this point, DesignCon 07 was just wrapped up. Right on the program guide's cover, the following 4 lines stating Design 07's themes are listed: Semiconductor and IP Technology; Verification Technology; Test and Measurement; PCB Technology. I have a feeling that DesignCon has a preference over the years to more lean towards verification, test and measurement as opposed to design, architecting and synthesis on one hand, and one the other hand, more on PCB side as opposed to chip side. As the mature of SoC and IP technology, the boundary between a system and a component becomes more and more blurred, and more and more prev. board-level systems becomes a single chip, thanks to the rapid advance of process technology and EDA methodology. Has the situation been improved this year? You bet

Now let's have a fresh look at what the challenges to the widening design productivity gap there. According to Prof. A. Richard Newton in a GSRC (GigaScale Research Enter), who just unfortunately passed away, the ever widening design productivity may lead to: expensive chips; inability to guarantee hitting market window; quality issues in the field, and that may further lead to industry slow down. Prof. Newton called for realizing the potential of giga-scale silicon by enabling heterogeneous component design with a single-pass route to silicon implementation from a microarchitecture, as the goal of GSRC, in a presentation he made in 2001. I think theoretically he is absolute right, while in reality, we have long ways to go in order to fulfill his dream as well as our dreams, as semiconductor technology keeps on shrinking, chip complexity keeps on increasing, so is chip operating frequency as well as the number of designers needed in any given design project.

Before we formulate possible solutions, let's first investigate why the design productivity gap is becoming even wider. Chips are designed by designers with the aid of EDA tools in a given design flow, a given design cycle within a given design team. Let us taking an IP-based SoC design as an example: at the front-end, from application to micro-architecture, is that purely manual? from micro-architecture to RTL, how many EDA companies, or those claimed ESL companies, dare to say that they could deliver 100% automatic, viable solutions (in terms of die size and performance comparable to manual approach) for chip architects? Is IP selection process still purely manual? Is IP integration process still ad-hoc? Are designs over-constrained that leads to the waste of die size and performance overhead in order to achieve timing closure? Is true DFM still far away while designers have to rely on DFY? Where is the full-fledge look-ahead capability in any stage of design phases so that a designer could roughly predict with a rapid what-if-analysis? IP-based SoC integration, platform-based SoC design, those buzzwords have been there many years, but where is the beef? No wonder so many ESL and DFM companies, the top tow hit spots in DAC last year and the year before last, are shifting their focuses for the survival reasons. I think as of today, the ever widening design gap is due to the unavailability pf next generation design methodology and associated tools that could take care of performance, die size, power and reliability by unifying synthesis and verification, both front-end and backend. It will be not working anymore if you, as an EDA vendor, claim your tools are targeting ASIC designers, or FPGA designers or SoC designers. Especially for SoC, with so many variations of targeted applications, so many variations of micro-architectures, it is hard to make a holy-grail EDA system that could east them for all. Here segmentation, differentiation and focus are the keys to formulate a competitive strategy. Now how about execution? Deliver or even over-deliver what you promise in your marketing hypes? Make your customers to have successful commercial tape-outs and then rock.

Historically before the formation of EDA industry in early 1980s, corporate CAD took the full responsibilities to develop in-house EDA tools to have designers in boosting their productivity by automating those routine jobs. Over the years, the rise of the EDA industry means the shrinking of corporate CAD efforts, and vice versa. Now we see the rise of corporate efforts again as the semiconductor technology main stream hits 65nm node, and EDA tools capability are 2 or 3 years behind design expectation. That reminds me that around 10 years ago, while semiconductor industry were crying on the rapid timing closure problem at the very-deep-sub-micro era, both Magma and Monterey started, with later on Magma went to public and Monterey went to south. It is an coincidence that, today I happened to visit Synopsys' website, and the just released a latest news on claiming their legal battle victory over Magma, so called a major step towards the infringement phase of the case, and then I went to Magma's site, and they claimed the court ruling is a major step toward the dismissal of infringement claims. I could say nothing more about this language battle, for the same YES, to the English speakers, it might means NO, while to the Chinese speakers, YES is strictly YES. Anyway despite the legal issues involved both with Magma and Synopsys, both as once shinning startups in 1980s and 1990s, both made revolutionary EDA breakthroughs in logic synthesis and physical synthesis respectively. I sincerely wish that in this decade, there will be another Magma or Synopys type success that could significantly changing the landscape of current design practice, and rapidly narrow the ever widening design productivity gap

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So this concludes my three-day of DesignCon 07 blog series. Hopefully see you guys on site at Designcon 08 at Santa Clara Convention Center.

DesignCon II - Aspring for Reconfigurable Computing

During the second day of DesignCon 07, Willem P. “Wim” Roelandts, President, Chief Executive Officer, and Chairman of the Board at Xilinx offered his keynote speech, There is a reason why FPGA vendors like Xilinx and Altera among others could survive and thrive, since CPU could not fill the performance gap that FPGA could deliver, of course with the associated cost. If the next generation computing paradigm could combine FPGA’s performance edge with CPU’s cost advantage, the world will be different. Will that be a new wave of heterogeneous computing, it could be. The challenge here is how to generalize the specialized hardware-based programming that FPGA delivers, and how to specialize the generalized software-based programming that CPU delivers. So AMD’s approach on combining CPU with GPU on a single die might be a wise way to go since they start from lightweight heterogeneous computing instead of heavyweight heterogeneous computing. I believe the taking off of heavyweight heterogeneous computing takes time. Anyway, according to Wim, semiconductor industry has been driven by system industry for many decades. Starting from mid-1970s, all the way through 1980s, 1990s and 2000s, we could see the rise and falling of semiconductor industry having dancing with Mini-computers in 1970s, PCs in 1980s, Internet in 1990s, and now Triple Play in 2000s. FPGA now has entered consumer electronics space as opposed to its traditional spaces on both aerospace, defense as well as network infrastructure spaces. Part of the reason is the costs of FPGA being continuing declining, and the performance of FPGA being continuing rising, thanks to the rapid advance of both SoC technology and semiconductor fabrication technology. FPGA nowadays becomes more and more hybrid as opposed to just a logic device, integrating hard cores as well as programmable fabric together, so called FPGA platform. In Wim’s vision, connectivity in this Triple Play decade is the key focus at least for Xilinx’s FPGA, both at infrastructure side and at periphery side. Imaging a start-of-the-art commercial FPGA device in 12-layer copper, 40 nm gate length (poly), 65 nm process could integrate 1 billion transistors, please note it’s not a memory device, it is a programmable logic device. Now what impresses me more is not the state-of-the-art FPGA devices offered by Xilinx now, instead it is Partial Reconfigurable Computing, a disruptive technology mentioned by Wim. Why partial? Because full mode is not realistic at this moment. The idea was straightforward, and I believe it has been there for around a decade. I still re I still remember around year 2,000 there were quite a few VC funded startups working on reconfigurable computing, such as Quicksilver, and all of them now went south. For FPGA, migrating from configuration-based computing to reconfigurable computing (adaptive) is just like migrating from single-programming to multi-programming for CPU. Of course, the former is hardware-based programmability, and the latter is software-based programmability. Imaging that while your smart phone originally designed for GSM based system, and roaming at country you go for a business trip that adopts CDMA system, and without a dual card, your smart phone automatically switches to CDMA mode from GSM mode through the reconfigurable FPGA chip inside your smart phone. Is that a dream? The day it becomes a reality will not that too far away. The challenge here is the real-time reconfiguration

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latency, while one piece of the logic is conducting current pipe of computing in the reconfigurable FPGA chip, the second piece of the logic is being configured for the next pipe of computing (a different kind of computing as opposed to the current one), and the third piece of the logic is calculating on what kind of configuration should be made for the phase after next computing. In that sense, such adaptive computing might produce a truly intelligent system, scared? It shall take long long time to go. For now, let's worry about partially reconfigurable computing first. The more haste, less speed, let's take one step a time, one solid step every time, of course.

DesignCon 07 I - Heterogenous Computing Is Taking Off

Before I start today's thesis, let me tell you one episode. Some of our non-technical readers asked me why Frontier Journal is so technical? My answer to them is that we are in high-tech industry that is why our publication is full of technical merits; Frontier Journal is of the high-tech industry, by the high-tech industry, and for the high-tech industry. Now, there are also some of our technical readers asked me why our publication now features a lot of business related topics, my answer to them is since we are in industry instead of academia, it is for high-tech business, not pure R & D, so we shall provide a forum for the leaders in our business to share their vision and insight with us. In brief, now Frontier Journal is positioned as High-tech Think Tank and Action Workbench. What do you think our new positioning? Feel free to contact me if you have any inputs for us, truly appreciate it.

Time runs fast, one year ago at the same time we were exhibiting at DesignCon 06 at Santa Clara Convention Center, and our Frontier Journal (at that time still called System Design Frontier Journal) were the hottest publication among those magazines freely distributed at the entrance of the exhibition hall. Now one year passed, this year DesignCon again put us as their media sponsor (<http://www.designcon.com/2007/sponsorship/sponsors.html>) However, due to logistical reasons, we have to skip this year's DesignCon. However, this does not prevent us from reporting and commenting on DesignCon 07, just like what we did for Davos 07.

So I watched the presentation in flash by Steve Polzin, Senior Fellow and Chief Platform Architect at AMD. In his presentation, he gave us an overview of the evolution of X86 process architecture, namely from 16 bit single core to CPU, to 32 bit single core CPU, to 64 bit single core CPU, and finally to today's 64 bit multi-core CPU, such as AMD's 64 bit dual core Opteron, and upcoming 64 bit quad core Barcelona. According to Steve, the Accelerating Computing efforts at AMD has evolved from platform-level (board-level) acceleration to silicon-level (chip-level) acceleration, thanks to the rapid advance of SoC technology and semiconductor process capability. Of course, when getting to multi-core integration in a single chip geared towards even higher performance that a single core CPU could never dream, there are both formidable hardware and software challenges. On the hardware side at the architecture level, according to Steve, system designers at AMD has to heavily rely on distributed architecture, (they call it Direct Connect Architecture and Enhanced Direct Architecture) in order to increase bandwidth, reduce latency when dealing with memory, I/O etc, since communication among on-chip modules becomes one the key bottlenecks in high-performance

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computing, and distributed architecture instead of centralized architecture is one of the viable and also obvious solutions. On the hard side at the implementation level, chip designers at AMD have to pay a great attention on power management, testing and characterization, cooling mechanisms, packaging, yield and manufacture costs. Now on the software side, both compatibility and programmability are of paramount importance. Of course, those CPUs are targeting both server and desktop application, the traditional AMD arena

Now what surprises me most from Steve's presentation, is, that, AMD is starting to enter mobile space. Of course, with the recent announcement of the adoption of Intel's mobile CPU by Apple's iPhone, the market for heavy-duty mobile CPU is truly taking off. According to Steve, the homogenous multi-core integration based high-performance computing soon will run out of gas, and the next paradigm shift would lie on heterogeneous computing, such as combining a CPU core with a GPU (Graphics Processing Unit) on a single die, with a single shared memory as well as fully integrated bus architecture. Of course, the immediate practical application for such a CPU & GPU combined SoC would be in 3C (Computing, Communication and Consume Electronics) based mobile application. Will iPhone also adopt AMD's solution someday? Why not? Just like Intel is fighting fiercely with AMD on server and desktop computing market.

So Heterogeneous Computing is taking off, that's my impression during the very first day of DesignCon, and my DesignCon 07 blog series will continue daily till it ends, so stay turned

Davos Forum VIII - The Commoditization of the Elite Class under Globalization

Today I watched the webcast titled A Business Manifesto for Globalization again, and I tend to agree with what Carlos Ghosn, CEO of Nissan and another car manufacturer in France, he claims that while people dealing with globalization today, those who are benefiting from globalization do not feel it, and those who are being hurt by globalization do feel it, and scream about it. Indeed there are cons and pros of globalization, there are pains and gains of globalization, there are joys and sadness of globalization, and there are winners and losers of globalization. However, if we look at globalization deeply, we will find that there is one thing is for sure, that is, the Commoditization of the Elite Class under globalization, for country, for business and for people.

In terms of countries, G7 used to be the elite class club, and with the addition of Russia, now it's G8, and people are talking about to expand G8 to include Brazil, India and China (BIC), some people even go further, they want to see a G13, can you believe that? There will be more and more countries that can be categorized as elite countries, and that means the commoditization of elite class at the country level. It is the change that brings to us by the globalization.

At business level, if you look at the change of entry barrier of being a Fortune 500, you won't be surprised we could easily expand Fortune 500 to Fortune 1,000 in a just a few years if we do

not raise the bar for the entry. Each year you can see more and more startups go public, being listed in many stock exchange markets worldwide, such as NYSE, NASDAQ among others. On the hand, competition in virtually every industry becomes more and more fierce, more and more business have to go and find their own blue ocean by combing the overall cost leadership and differentiation as competitive strategy in order to gain their competitive advantage. That means the commoditization of elite class at the business level.

Now if under globalization, some countries gain more through their business expansion in other countries, while some other countries lose because of their loss of domestic markets; at individual-level, that mean more job opportunities or less job opportunities, increasing salary or decreasing salary, hence better living standards or worse living standards. In those developed countries, while their transnationals are gaining more market shares in those developing countries, not only their blue collars in the manufacture sector, but also those white collars at the service sector, such as lawyers, doctors, dentists, issuance agents, stock brokers, journalists among others, are feeling being threatened on job security since more and more jobs in their sector being outsourced to those emerging countries, such as Indian and China. That is a crystal clear demonstration of the commoditization of the elite class at the individual level. I believe most of the negative side of globalization are coming from the individual level, since democracy in those developed countries drive those politicians to speak up for their fellow citizens, the used to be elite class, now the scapegoat of the globalization

While all of the above all are true, personally I am quite optimistic on globalization, since I believe everything might be outsource, however, you could not outsource your innovation, and if you are good at innovation, which could serve as your unfair advantage, then no one could replace you being as part of elite class, whether as a country, a business, or an individual.

So under globalization, what are we competing for? No overall cost of leadership any more, it is Innovation that could truly make us standing out in a crowded and commoditized world.

This concludes my Davos Forum series, hopefully see you in person at Davos Forum 2008 on site, and I shall report for you live there at that time

Davos Forum VIII - Setting Your Agenda before Shaping it

This post is also listed at <http://www.forumblog.org/> and <http://www.davosconversation.org>

- “I think there is a world market for maybe five computers.”
–Thomas Watson, chairman of IBM, 1943
- “There is no reason anyone would want a computer in their home.”
–Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977
- “640K ought to be enough for anybody.”
–Bill Gates, 1981

I think if you are familiar with today's technology, you won't be surprised how ridiculous the above forecasts were, and those forecasts were all made by those visionaries, who shaped the agendas at their times and some of them are shaping our agenda now. Now let me show you the following forecast who was freshly made:

- The World Only Needs Five Computers - ... Let's see, the Google grid is one. Microsoft's live.com is two. Yahoo!, Amazon.com, eBay, Salesforce.com are three, four, five and six. — I'll bet at least one, maybe the largest, will be the Great Computer of China) ... - Greg Papadopoulos, CTO of Sun Microsystems

So is it back to old days again? Yes and no. Let's put aside technical details on why computing paradigm is shifting to old ways again, one thing is for sure. That is, the future is hard to be predicted; hence the agenda is tough to be set, it holds for both elites and grassroots. For you to understand my agenda better before shaping it together, let me show you a few more examples, before yahoo! went to public, who knew it was a huge business opportunity for online ads except both Jerry Yang, David Filo and a few VCs who visited Yahoo!'s old office located at a garage? Who would imagine the wild popularity of both myspace and youtube except their co-founders as well as a few VCs? When I was a fresh graduate student in the Fall of 1994, saw the system administrator at our Lab who set up Mosaic web sever and browser clients for us, I never thought that it could led to quite a few successful IPOs, just to name a few: Netscape, Yahoo!, amazon, ebay among others. Even for seasoned entrepreneur and angel investor like Rob Ryan, the founder of Ascend and Entrepreneur America, in his book titled Entrepreneur America, expressed his regret on not investing on Pierre Omidyar's eBay, which cost his opportunity on increasing his fortune even more significantly. On the other hand, the smart angel investor might be Andy Bechtolsheim, who wrote a check in the amount of less than his half year's salary for tow co-founders of google, and generated a ROI that no one could ever imagine after google went to public.

So I would suggest all of us, whether for our business, for our country, or for our world, setting the agenda first, even primary, and then shape. Shaping an unsettled agenda is like driving on a frozen lake, it is way too dangerous.

Davos Forum VII ~ The Solution - Narrowing the Widening Gap

This post is also listed at <http://www.forumblog.org/> and <http://www.davosconversation.org>

As I mentioned in my yesterday's post, amid the huge growth opportunity at the inflection point of the New Economy, we have to seriously think about the formidable challenge we face right now: that is neither energy conservation, nor climate preservation, since those issues I would like to call them second-hand issues, that we should worry about in decades, if not in hundreds of years. Please let me clarify myself, it does not mean both energy conservation and climate preservation are not that important, in fact they are important, but not as important as keeping a peaceful world for all of us to survive and prosper. Keeping a peaceful world should

be on the prime position of any growth agenda. Without address this most important issue, it is like teach a kid who could barely walk on how to play golf.

So what is the solution for the challenge to secure a peaceful world in order to sustain and forge economical growth? First of all, there is no silver bullet. However, if we look at the issues we are facing in today's dynamic yet risky world, most of them are due to conflicts, and those conflicts have triggered and are triggering wars, both military and trade wars among many countries. Why? because the old order of the old economy are being destroyed, and the new order of the old economy has to been established yet. During this transition period, much more conflicts, both economical and political, are being produced. If you look at the history, many major wars happened during the transition period, and we should warn all of ourselves, we, as rational people, should not allow such kind of tragedies happen again in our life time for the God's sake. No more fight please.

From my perspective, those new conflicts are coming from the ever widening gaps between those rich (developed) countries and poor (developing and emerging countries) at country level, between those transnationals and those family business (or something like that), and between those rich people and those poor people at individual level. Let us take the business world as an example. We all endorse market economy, and market economy encourages competition-based entrepreneurship, which creates job opportunities for those non-entrepreneurs and contributes to the society through taxation among other social responsibilities. Those are all reasonable, however, the labor-capital relationship may not be sustainable in case anything unfair opposed to the labor side, or to the capital side, as we head of news on strikes at some countries in the Europe. So maintain a healthy labor-capital relationship through balancing is utmost important for a business to succeed. The same principle applies to the world affairs and individual level. No country wants its constant trade deficits, and no country wants its domestic markets dominated by those foreign companies. No people wants to staying poverty, and no people wants to stay in ignorance. So if those rich countries could think about more on how to help those poor countries in whatever means, and those rich people could think about more about how to help those people, we might narrow the widening gap. Of course nothing should go extreme, for example, tax reduction might favor those rich, and stimulate more investment opportunities, hence create more job opportunities, but heavy tax reduction might impact those poor who rely on welfare. Again balancing is the only way to go to solve such a chicken-and-egg problem

Attitude is everything, let us stay calm and work hard, to secure a peaceful and prosperous world – Let us compete instead of fight!

Davos Forum VI ~ The Challenge - Soft Landing, Hard Landing and No Landing

This post is also listed at <http://www.forumblog.org/> and <http://www.davosconversation.org>

This morning before I downloaded and listened to yesterday's Podcast files from Davos Forum website, I listened to the podcast of the panel titled Update 2007: The Global Economy again, I

was impressed by those panelists' insights. While most of those panelists are favoring the prospect of a soft landing, there is at least one panelist insists a hard landing might be inevitable. Whether soft landing, hard landing, or even no landing, the toughest challenge is the unbalancing, and the gap is becoming wider and wider, I shall address the solution on how to close the gap in my next post. For now, let me elaborate to you why we should be extremely cautious on the challenge ahead

When we consider economical issues that may impact our growth, such as growing trade deficits of those developed countries, energy conservation problems in those emerging countries and developing countries, please do not forget there are quite a few hot spots in the world, such as Middle East, East Asia and Part of Africa, which instability might trigger bigger regional wars or even the next war. If that kind of incidents happens, forget about soft landing and hard landing at all, since there will be no landing at all, no matter how skilled your pilots are, and no matter which advanced space shuttle you are riding with. No doubt politics is one of the most important drivers of economics in any country under any system, without political stability, talking about economic growth is like joking around at a cocktail party during weekends. Let me give you an example on how weak the New Economy we are working with is, several weeks ago, several earthquake occurred at Taiwan Strait, and that broke quite a few backbones made in fibers that connecting the US and China. Our outsourcing business relies on the Internet very much, since most of our clients are headquartered in the US, so you may imagine the significant reduction of our staffs' productivity during past several weeks. Just only because the Internet connection becomes much slower, since the same amount of Internet traffic has to go through from less fiber connections due to the damage made by the recent earthquake. As of today, while I am composing this post, our Internet connection is back to normal speed, and I am glad to this recovery. Now for those transnationals, such as FedEx, UPS, eBay, Paypal, aVis, American Airlines among others, how much was the impact to their daily business practice? Can you imagine what will happen if wars occur instead of natural disasters anywhere in the world? Your Internet connection will be lost, your car cannot find gas supplies, even worse, and your grocery stores may not supply enough foods to you and your family.

In my life so far, I personally experienced two wars, one was in 1979, when I was still in my elementary school, a war occurred between China and Vietnam, and that only lasted a couple of weeks, it did not impact our daily life that much. But I still remember all of our neighbors gathered together to watch TV on gathering the latest of the war. The second war I experienced was right on the morning of 9/11/2001, when I got up and open up my home computer screen, I found there were 2 photos at the very first page of AOL website, with 2 jets hitting 2 skyrockets (the World Trade Tower), I was thinking it might be a Fool's Day type trick. Now when I turned on my TV, I found it was indeed a war triggered by those terrorists. I think most of you might feel the impact of the war against terrorists since 9/11.

As I mentioned in one of my prev. posts, any one who is rational would like to experience any war, would you like to risk your own life, or your fellow citizens' life to fight in the battlefields. In human society, through long history, conflicts are inevitable, all of us shall sit

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down calmly, and find viable solutions to resolve conflicts and make our life peaceful and beautiful. How? Please check up my next post titled: The Solution - Closing the Gap. So stay turned

Davos Forum V - The Source of Next Generation of Power

This post is also listed at <http://www.forumblog.org/>

This morning I got very early to download podcast files of the very day of Davos Forum, and listened to them. This is the second time I listened to Dr. Angela Merkel, the German Chancellor, the first time I did was at Hannover Congress during CeBIT 2006, she gave the Opening Address for the CeBIT (for my impression on her Opening Address at that time, please refer to my prev. blog at <http://www.hwswworld.com/wp/?p=49>). Chancellor Merkel divided countries in the work into three categories: developed countries such as G8, emerging countries such as Brazil, Indian and China (so called BIC), and developing countries for the remaining.

The impression I got from Chancellor's Opening Address is, that, she is much concerned about the downside of globalization from a leader of developed country's perspective. According to Prof. Michael Porter a Harvard Business School, the author of both Competitive Strategy and Competitive Advantage, there are 3 fundamental competitive strategies, namely, overall cost leadership, focus and differentiation. So at least at this stage, the source of power for any country to succeed in economical competition is still overall cost leadership, and that can be translated to the size of population hence the size of market a country possess, the amount of energy and other raw materials a country could reach, as the current generation of technology becomes commoditized now. As more and more transnationals set up their branches outside their home countries, where most of them are located at those developed countries, concerns for capital migration and job loss becomes more and more severe in those developed countries, both the general public and the politicians.

So based on here observation, Chancellor Merkel calls for anti-isolationism and pro-liberalism in order to reduce global imbalances, minimize financial risks as well as improve intellectual property rights protection. But deeper integration to fully embracing globalization should be directional, there is long way to go on fully opening up markets and eliminating trade barriers. For any country, political and economical stability is of paramount importance; it is so called The More Haste, Less Speed.

I believe from now on, the source of power will lie on innovation, which comes from your, his/her and my mind, instead of from things like population, natural resources etc. If you look at Japan, a country without any natural resources per se, and Finland, a country with its population even less that that of Shanghai, what can you say on the importance of innovation in being the driver of a strong economy, and being served as the source of power

As I mentioned in my prev. post, the powering shifting will be back and forth instead of one-directional, as the capability of innovation is independent of a country's population size and natural resources capacity. Innovation can always produce next generation technology that is non-commoditized for a certain period, and the innovation process can be repetitive. If you look at US, why US is so strong in high-tech sector? That is largely due to their graduate schools' attracting thousands of highly-gifted students from all over the world, further-educated them, and sending them to local industries or local academia, most of those people later on get naturalized as permanent residents and/or citizens of the US. So nowadays, a country with small population size still could be highly competitive through innovation based on aggressive immigration policies, countries like Canada and Australia can all be fit into that category. So the source of next generation power is innovation, and the driver of innovation is people. Whether for a business or a country, people, especially those elites are where innovation comes from, and those grassroots are who endorsing innovation, and turning innovation into productivity for power

So what shall we when facing the big wave of globalization? Be open-minded instead of narrow-mind and act now to fully embrace it, any time, anywhere in anyway!

Davos Forum IV - A Fresh Look at Power Shifting

This post is also listed at <http://www.forumblog.org/>

Davos Forum 2007 will start from today in just a few hours, and the five-day meeting's theme is "Shaping the Global Agenda: The Shifting Power Equation". With the inevitable adoption of global localization and local globalization, the world is indeed becoming a village, thanks to the rapid innovation in both technology and business process. Typically people agree that the power, whether economic or non-economic, are starting shifting from those developed countries to those developing countries, or so called emerging countries, such as China, India and Brazil among others. In certain sense, that is right, partly due to the size of those developing markets and the size of that affordable yet high-quality labor pool in those developing countries. However, we should never underestimate the power of those developed countries, such as US, UK, Germany, Japan among others. I believe the power is shifting indeed, but it is definitely not one-way, it's two-way, and the shifting paradigm is back and forth. Why? Since the source of shifting power is not just market size, labor pool size any more in the New Economy. The fundamental source of next generation power shifting will be innovation, and in that sense, all countries are equal to compete on innovation capability, whether you are big or small, rich or poor, developed or developing. I think it is good to all of us, as a global citizen, fair competition through free trade is a great way to enhance our material life as well as spiritual wealth. For those developing countries in rapid progress, it might be better for them to pay more attention to environmental issues, intellectual property issues among others while accelerating aggressively; and for those developing countries, it is might be good for them to recall how they emerged from developing countries to developed one decades ago or a century ago. For both developing countries and developed countries, we all should remember that, No Pain, No Gain, and a balance between short-term interests and long-term

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interests is a good way to go. It is all about attitude, let us keep positive attitude towards the Change, or the Shifting of Chang. In MBA buzzword, that is called Change Management anyway.

Between War and Peace, no one, if rational, wants war, no matter economic wars or military wars, instead of peace. Looking back from the history, many military wars were triggered due to economic conflicts, could they be prevented? Of course, one evidence is, since World War II, we have enjoyed many decades of peace, despite of numerous regional conflicts, thanks to the World Security Council under the United Nations and the WTO. The balance of power, whether politically or economically are difficult, especially when during power shifting stage, that requires the political and economical wisdoms of our leaders, as well as fellow global citizens like you and me. Nowadays, you can voice and people might listen to you if you are right. Davos Forum is a great place for people to voice, this year it is still for those elites, maybe next year there will be some representatives of grassroots to be invited to speak up there. As I used to say, the Beauty of Life Is Its Uncertainty, Be creative and use your imagination, let us make our life even more beautiful together in this rapidly changing world

Davos Forum III - The Creator of History, Elites or Grassroots?

Our Frontier Blog's posts on Davos Forum is now also published at Davos Forum's 2 official blog sites: <http://www.forumblog.org/> and <http://www.davosconversation.org>

The annual meeting for Davos Forum will start tomorrow, as more than 2,000 business leaders and more than 200 public figures gather together at the small yet famous town in Switzerland, what can we expect from those elites in our times? Nowadays as the media becomes more and more advanced, TV, radio, newspapers, magazines, Internet. People at the every corner of the world can know instantly know what happens at the other end of world at anytime, anywhere in anyway. Furthermore, not only just being as passive watchers, people now are allowed to be active even proactive participants by publishing their own opinions through text, audio and video blogging, even in a world leading forum such as Davos Forum. The World Is indeed Flat in that sense

Davos Forum, with its official name as World Economic Forum, is definitely a forum for those elites of elites. That remind me to recall when I interviewed Prof. Aumann, 2005 Nobel Prier Winner in Economics (<http://www.hwswworld.com/uploaddownload/aumann.mp3>) One of my raised questions was who are the driver of the economic progress, elites or grassroots. His answer to my question was it is a combination of both. Indeed I fully agree with him, who built the Pyramid, the Great Wall among other world wonders in old days? Why are maintaining and enriching Wiki, making craislist a true online community, populating myspace - they were/are all grassroots. Of course, we have to admit that, people are born unequal, in terms of family background, IQ and EQ, and people's achievements may vary significantly during their lifetime. Furthermore, without strong leadership, any government or business cannot succeed under tough competition. Some people may favor natural selection, while others endorse intelligent design that is not an issue. The truth is, through the entire history so far, the creator

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of history is you, me and other people like us, whether as elite or grassroots. The widespread of web 2.0, such as blog, wiki, podcast, and secondlife among others, is making grassroots being much more important than that of in old days.

So hurry up, voicing yourself at Davos Forum physically by booking a last minute expensive air ticket now or spiritually by blogging at Davos Forum Blog, just like what I am doing now

Davos Forum II - The World Is Small, The Universe Is Big

It was a pity since we missed the deadline for media participation application to report at World Economics Forum at Davos during 1/24 and 1/28. I do hope next January I shall fly to Switzerland to show up at Davos Forum, get a chance to conduct field reporting through daily blogging (even hourly blogging if necessary), lunch meeting, as well as live interviewing with those visionary leaders in industries, academia as well as governments, just as what I did during DAC 2006 at San Francisco (http://www.hwswworld.com/interview_dac.php and http://www.hwswworld.com/interview_lunch.php) Of course, even if not physically attending the forum, it does not prevent us on reporting and commenting on the world class elite summit, thanks to the Internet. As technologies advance in such a rapidly pace, distance is not a problem any more. For example, our upcoming Frontier Visionary Panel, with panelists confirmed so far consists of world class technology gurus and as well as business leaders, will be conducted in a unconventional way (<http://www.hwswworld.com/interview.php>). So do we still need trade shows, conferences as well as forums? yes, we do in certain sense, face-to-face communication, albeit with the expensive costs in terms of money and time, it is still the most effective and efficient way, that is why Frontier Journal is happy to be the Media Sponsor of DesignCon 2007 (<http://www.designcon.com/2007>). A good analogy is on movie watching, would you like to rent a video tape from nearby Blockbuster store or rent it online from netflix.com, or drive to your nearby Century Cinemas or things like that? For most people including me, of course, enjoying a movie at a cinema is much better than watching a vide tape at home.

More than one week ago, Time Magazine published a cover story writen by several of its correspondents from all over the world titled The Chinese Century, claiming China might take over the US as the world super-power in the century peacefully. Now this might be a compliment or good news to Chinese, is that a bad news to American? I do not think so. Just like what happens in business world, for any country in world affairs, to gain competitive advantages through competitive strategy, it is not necessary to be as a winner by making your competitor(s) as loser(s). It is most likely that a win-win scenario could be created in gaining mutual prosperity in a globalized, tightly integrated economy. so whether you a Chinese citizen, a US citizen, or a citizen of a country other than China and US, it is not important for you, as a global citizen, should push respective government to forge a peaceful atmosphere that could facilitate wealth creation, power reduction and spirit enhancement, and make our globe much more secure as well as comfortable. Winning without battling, even economically such as through trade wars, reducing conflicts through peaceful negotiations and settlement should be the top priority in today's world affairs. Looking back in the human being's history, who cares as of today, that Roman Empire, or even the most recent falling of British Empire? United

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Kingdom, as a developed country with glorious history, is still highly competitive in high-tech, and immigrates lots of high-tech elites to countries like US, Canada as well as Austria, and they are thriving again during past several decades. It is really does not matter for any country ups and downs in the river of the history - - The World Is Small, yet the Universe Is Big

This year Davos Forum unveiled the program for its Annual Meeting, under the overarching theme of 'Shaping the Global Agenda, The Shifting Power Equation', leaders from all over the world will share their visions and insights on the impact of The Shifting Power Equation, and let sit down, take a breath, watch and listen what they would deliver to us. I think, any one, whether as an individual, a business, or a country, if he or she gets rid off his or here Winner's and Loser's Attitude, and fully embrace Participant's Attitude, then the future will be bright for everyone.

So participate by being an actor or actress in your personal life as well as business life, make our world peaceful, enjoyable and prosperous, since Living is Writing, and Life is a Drama

Davos Forum I - Frontier Blog with Davos Forum

I think very few of you, as one of our readers, who have not heard of World Economics Forum, or Davos Forum, with it major forum (it has quite a few other regional forums) being held at Davos, a small town in Switzerland. Davos Forum, typically held during the last week of each January, attracts several thousands of industry leaders (most of them from Fortune 500), top government officials from many countries, as well as reporters worldwide. It is indeed a big gathering of elites in business and public sectors in brainstorming their ideas, in sharing their visions and insights to the rest of us. People from high-tech industries of course are part of such big gathering

This year Davos Forum goes really high-tech, they are actually get into web 2.0, besides Forum Blog setup at (<http://wef.typepad.com/blog/> or <http://www.weforum.org/> and click on Weblog) (our Frontier Blog now is listed there side to side with those Blogs from Newsweek, Time Magazine, BBC and Business Week among other main stream media), they also go to SecondLife for virtual reporting. For a top niche forum as conservative as Davos Forum, one can hardly imagine that their attitude towards new technologies are so aggressive and bold.

So as one of the major contributor of this blog, in the coming weeks towards the end of this year's Davos Forum, I shall write a series of blogs about Davos Forum for sure, please stay turned

Prof. Orit Hazzan's Column

Agile Software Development and the Nature of Software Development

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In my previous columns, I proposed that many of the unique properties of software development processes stem from the fact that software is an intangible product. In this column, I will elaborate on two properties of software development processes that are derived directly from this characteristic and I will show how agile software development helps us cope systematically with problems associated with these two properties.

The first property derived from the fact that software is an intangible product is the non-transparent nature of a typical software development process. In other words, when dealing with an intangible object, how can we know exactly what stage the development process is at, what has been accomplished by the teammates so far, what units or modules have already been tested, and so on. The second characteristic of software development processes that stems from software intangibility is cognitive complexity; indeed, the design process of an intangible product is more difficult than that of a tangible product, testing processes are simpler with tangible products, and even the comprehension process of software is considered to be a complicated cognitive process.

Examination of these three properties – intangibility, non-transparency and complexity – reveal that while software intangibility is a given, unchangeable fact, we *can* make the development process of software more transparent and supply tools for coping with its cognitive complexity. In fact, in most cases a correlation exists between the two: when we make the process more transparent, we also support its cognitive complexity; and vice versa, when we cope cognitively with the given complexity, we make the process more transparent.

In what follows, I will analyze agile software development from this standpoint. I will show how the different basic agile concepts increase project visibility, making the development process more transparent and reducing its cognitive complexity. This analysis is presented in the following table.

Agile Concept	Increment in project visibility	Reduction in cognitive complexity
Whole team	This concept implies that all team members sit together in one space, including role holders that traditionally belong to separate teams (e.g., testers and designers). In this development environment, the walls serve as a means of communication, constituting an informative workspace. Among other informative items that the team decides on, the information posted on the walls includes the status of the personal tasks that belong to the current iteration and the measures taken. Thus, all participants can see all of the goings-on, all of the time. In addition, the entire team holds daily stand-up meetings, which usually take place in the morning. In these meetings, each team member presents the status of what he or she accomplished the day before and what he or she plans to do during the day to come.	Within the whole team concept, each team member has an additional role, in addition to being a developer. The rationale for this role distribution is that one person, usually, the team leader, no matter how skilled he or she is, can not handle in a professional manner all of the essential and complex responsibilities involved in software development processes. The distribution of responsibilities in the form of roles, helps to control these responsibilities, thus reducing cognitive complexity. In addition, this scheme increases project visibility because its application implies that all team members are involved in all parts of the developed software, each from his or her role perspective.
Short releases	The actual and detailed plan of the short releases and iterations is executed using of a practice called the planning game, in which all relevant parties participate – customer, team members, management representatives, and so on. This activity, which usually takes a full day, includes a presentation of what was developed in the previous iteration along with any relevant measures taken, and the planning of the next	It is well known that customers cannot define their desired software system at the beginning of the development process. The practice of short releases enables them to construct their knowledge gradually, based on what they see during each iteration. During this process, the developers also improve their understanding of what should be developed, partially due to the fact that they get to hear the requirements directly from the customer during

Agile Concept	Increment in project visibility	Reduction in cognitive complexity
	iteration. At the end of the day, a balanced workload is ensured among all team members. In the course of this day, a reflection process is also facilitated, in which the development process performed so far is analyzed and lessons learnt. Clearly, the fact that all sides participate in this day, the nature of the activities that take place during the day, and the fact that it takes place every week or two, all increase process visibility and make the entire development process more transparent.	the planning game. Another means by which cognitive complexity is addressed by the concept of short releases is the movement between levels of abstraction. In the traditional development process, each team member (role) usually perceives the software system on a single level of abstraction during the entire development process, a fact that sometimes influences his or her ability to grasp the whole picture. Short releases and the planning game practice lead all team members to move between abstraction levels and to improve their understanding of the developed software gradually and periodically.
<i>Time estimations</i>	In agile software development, the teammate who is in charge of a development task also estimates the time needed for its development. Clearly, this increases the teammate's responsibility to perform well and also enhances process transparency. The message conveyed is that all teammates know what each practitioner has committed to in terms of development time estimations.	The greater the task, the harder it is to estimate its development time. To cope with this challenge, in agile software development estimations are made with respect to small development tasks. As a result, it is easier to estimate their development time. Clearly, this approach reduces the cognitive complexity. Furthermore, since it is known that the smaller the segment estimated, the more accurate the development time estimation is, the development pace can be planned more precisely. Hence, once again, the transparency of the development process is increased.
	Measures are an essential element of agile software development. With respect to	Measures can lead the development team to simplify and improve the developed software,

Agile Concept	Increment in project visibility	Reduction in cognitive complexity
<i>Measures</i>	the discussion presented in this column, this means that visible measures are used to increase the transparency of the development process.	thus reducing its cognitive complexity. For example, if we measure the number of successful tests (tests that pass), and that number increases, then we can analyze this successful testing process in order to get an easier development process from a cognitive perspective.
<i>Customer involvement</i>	In agile software development, all team members have access to the customer during the entire development process. This is particularly true during the planning game, in which all team members communicate with hear the customer, as mentioned earlier. Clearly, this direct communication channel enhances both the process transparency and the chances that the software requirements are communicated correctly.	Direct communication with the customer eliminates the developers' need to speculate what the customer requires and then later introduce changes if it turns out that such speculations are incompatible with the customers' actual needs. Clearly, cognitive complexity is reduced by this kind of communication: first, there is no need to speculate ("what does the customer want?"); second, the overhead of dealing with change introduction at later stages is reduced significantly.
<i>Testing</i>	Since testing is an integral part of an agile software development process, the shift of responsibility over to another department, namely the QA department, is eliminated. This fact ensures a more transparent process because it is clear who is in charge of testing each developed unit. Furthermore, acceptance tests, which are defined by the customer and outline how each functionality should be tested, clarify the requirements and lead to a more transparent and clear process.	Agile testing processes consist of automatic test-first unit tests. This means that automated tests are written prior to the writing of the unit in a gradual process whereby each step introduces and tests an additional small functionality. This implies that thought must be given to the development task before actual coding begins. Also, dealing with automatic unit testing helps control the development process. Such a process clarifies what has been developed and tested so far and, hence, cognitive complexity is reduced.
	Among the different agile	When programming in pairs, is it

Agile Concept	Increment in project visibility	Reduction in cognitive complexity
<i>Pair programming</i>	practices that deal with the actual coding, I focus here on pair programming. With respect to the discussion presented in this column, this practice implies that all team members become familiar with all parts of the software and thus process transparency is increased.	harder to be distracted and, hence, pairs tend to remain focused on the development task. In addition, each task is perceived on two levels of abstraction: that of the navigator (higher level of abstraction) and that of the driver (lower level of abstraction). This practice clearly helps coping with cognitive complexity.

This, of course, is not the entire story. Additional agile practices exist that support development processes in similar ways, by increasing process transparency and reducing cognitive complexity. For example, refactoring, which guides developers to improve code readability without adding functionality, leads them to improve the code, and legitimizes doing so without being pushed to the next development task. Refactoring also acknowledges that one cannot, a priori, predict all development details, and that therefore it is legitimate to dedicate time to software improvement in order to increase its readability. In turn, the application of this practice reduces cognitive complexity and increases process transparency.

The above analysis further explains the positive results obtained by agile teams that not only refer to technical issues, such as shorter time-to-market and less bugs, but also improve feelings involved in the development process, such as team morale and business/IT alignment (see, for example, the *VersionOne's Agile Development: Results Delivered* report at http://www.versionone.net/pdf/AgileDevelopment_ResultsDelivered.pdf).

Analog Devices Column

Digital Isolation Offers Compact, Low-Cost Solutions to Challenging Design Problems

David Krakauer

INTRODUCTION

For designers of isolated systems, rapid advances in digital isolation technology are yielding new capabilities that greatly simplify their job. Examples include integrated, isolated power and truly bidirectional isolation channels that can reduce system costs and save circuit-board real estate. These advances are fueled by a shift away from LED-based optocouplers toward newer isolator technologies that are compatible with standard foundry CMOS processes. They enable integrated circuitry to be packaged with chip-scale microtransformers, thus fitting more functionality into a single package.

This article discusses two kinds of devices that embody these advances. In the first example, *isolated power*, chip-scale microtransformers are complemented by switches, rectifiers, and regulators to produce an isolated, regulated dc-to-dc converter; when integrated with isolated data channels it provides a complete isolation solution. In the second example, *bidirectional isolation*, integrating the requisite buffers and drivers creates an isolator that has truly bidirectional isolation channels without the need for external signal conditioning.

Isolated Power: *isoPower*

Galvanic isolation is employed to transmit data and/or power across a safety barrier, while also blocking charge or current flow across that barrier. The Analog Devices *iCoupler* family of digital isolators uses chip-scale microtransformers to provide cost-effective, space-efficient isolation. *iCoupler* technology was introduced in *iCoupler Digital Isolators Protect RS-232, RS-485, and CAN Buses in Industrial, Instrumentation, and Computer Applications* (*Analog Dialogue* 39-10, October 2005).

Figure 1 shows a 4-channel digital isolator, which houses three dice in a single package. Two CMOS interface circuits (left and right) integrate *drive* and *receive* electronics. The middle die contains four chip-scale microtransformers, each comprising metal (AlCu and Au) coils on either side of a 20- μ m polyimide insulation layer. The polyimide is capable of withstanding more than 5 kV rms for one minute.

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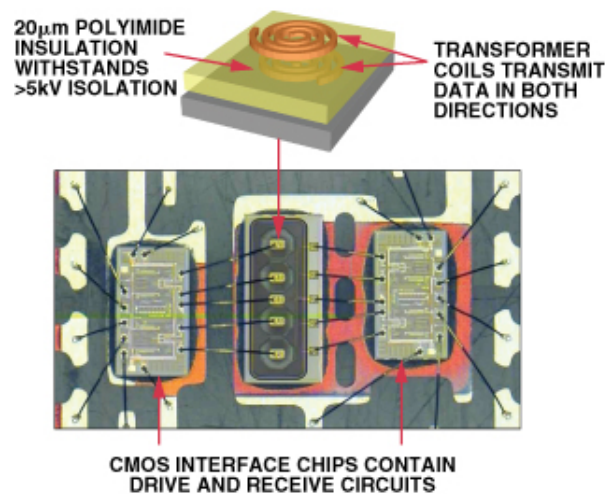


Figure 1. Construction of iCoupler digital isolator.

Unfortunately, in most applications that require isolated data transmission, isolated power must be available on both sides of the isolation barrier, or it must be provided separately. System designers typically introduce isolated power by designing an isolated power supply using discrete components—including a transformer with the appropriate isolation rating—or by purchasing a commercial off-the-shelf isolated dc-to-dc converter.

Each approach has its advantages and disadvantages. In the first instance, isolated power supplies may be custom tailored to an application, allowing system designers to optimize their cost, isolation rating, power output, or other important specifications depending on the application requirements. The downside, however, is that custom solutions tend to be bulky, require safety certification, and can lengthen development times.

Commercially available isolated power supplies, on the other hand, can reduce time to market, but they carry a price penalty and may not be optimized to fit a particular application. While smaller in size than their custom counterparts, they are still fairly bulky, with only limited availability of surface-mount package options.

A third way is *isoPower*, which combines the benefits of both options. *iCoupler* digital isolators condition and drive data across the transformers as described in the article, *High Speed Digital Isolators Using Microscale On-Chip Transformers*. *isoPower* uses the same chip-scale microtransformer technology, but instead of transmitting only data, *isoPower* employs switches, rectifiers, and regulators to generate power that is isolated to the same degree as the data channels.

Figure 2 shows the isolated power section of the [ADuM5240](#), [ADuM5241](#), and [ADuM5242](#), the first *iCoupler* products with *isoPower*. Four cross-coupled CMOS switches generate an ac

waveform that drives the transformer. On the isolated side, Schottky diodes rectify the ac signal. The rectified signal is passed to a linear regulator, which maintains the output voltage at a nominal 5-V setpoint. Efficiency can be significantly improved by giving up one of the isolation channels to provide feedback across the isolation barrier to the transformer switches.

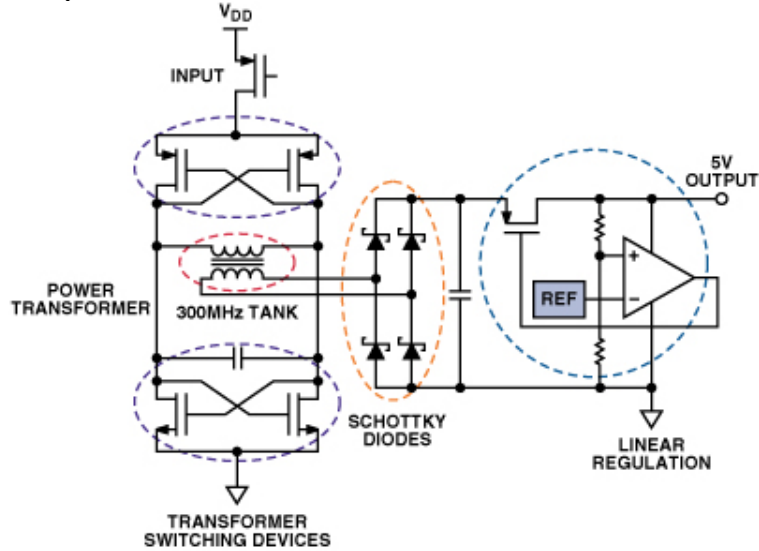


Figure 2. *isoPower* digital isolator implements isolated power.

Figure 3 depicts the transformers used in the ADuM524x family. The chip-scale microtransformers are made from 6- μm thick gold, separated by a 20- μm polyimide insulation layer, which is capable of providing greater than 5-kV rms isolation. Because the transformer coils, only 600 μm in diameter, have a low L/R ratio compared with conventional transformers, high-efficiency power generation requires high-frequency switching on the order of 300 MHz.

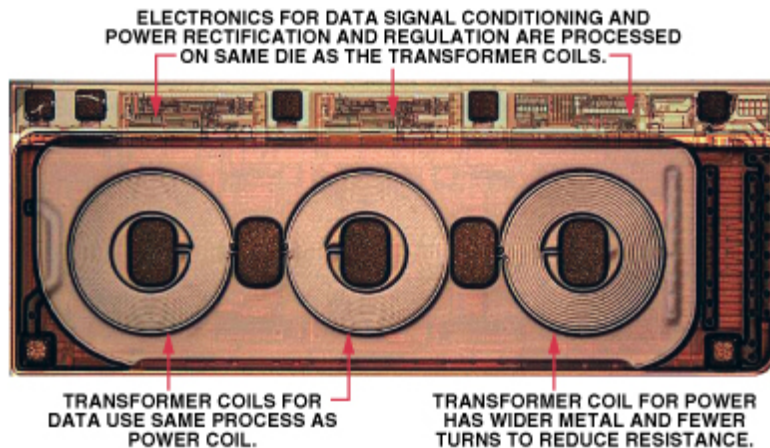


Figure 3. Chip-scale microtransformers.

As noted earlier, the transformers used to generate power employ the same process as those used to isolate data. The only significant difference between data and power channels is the conditioning circuitry on either side of the isolation barrier.

isoPower Example

Combining data and power in a single, small, surface-mountable package, the ADuM524x family provides significant size and cost savings. Figure 4 shows typical physical configurations for isolated SPI interfaces. The *iCoupler*-and-*isoPower* solution (Figure 4a) uses an ADuM5240 and an ADuM1201 to provide four channels of isolated data and up to 50 mW of isolated power, enough to power an ADC and a remote sensor. It is more compact and less expensive than the traditional approach using three optocouplers and an isolated dc-to-dc converter (Figure 4b). A third solution, using discrete transformers and other components, would consume even more area. Other combinations of ADuM524x *isoPower* and ADuM120x *iCoupler* products are possible, as are combinations of ADuM524x and most other *iCoupler* products.

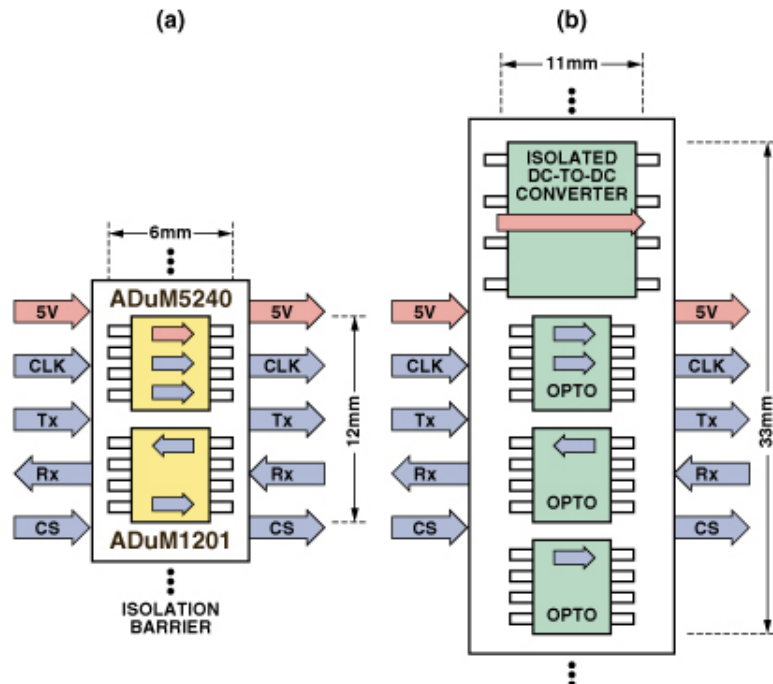


Figure 4. Isolated SPI interface using *iCoupler* technology (a) and optocouplers (b).

The small size and low cost of an *isoPower* solution opens up new possibilities for the placement and distribution of isolated sensors and reduces the cost of existing solutions, thereby enabling wider adoption of isolated sensors.

A case in point is turbidity sensors: they measure the amount of particulates in a liquid solution and can be used to determine the cleanliness of a volume of water. They are increasingly being used in home appliances, such as dishwashers and washing machines, both to conserve water and to improve cleaning performance. Conventional appliances wash or rinse for a set time, overestimating the required level of cleaning to ensure that the load is fully clean at the end of the cycle. A turbidity sensor, however, can let the system know when to stop cleaning. The machine will use the optimal amount of water for the optimal time, thus minimizing waste while maximizing useful cleaning performance.

Because turbidity sensors must be immersed in the water, they present two challenges to an appliance designer. First, the sensor must be small enough to fit unobtrusively anywhere within the space where clothes or dishes are to be placed. The size of the sensor is, therefore, critical. Second, the powered circuit is immersed in water, so the sensor must be safely isolated from the rest of the system. If the physical insulation should fail, the user and the system electronics must not be harmed, and there must be no possibility of fire. Both the power and the data must therefore be isolated.

The block diagram shown in Figure 5 demonstrates a cost-effective solution. The AD7823 low-power ADC uses a 3-wire interface to convert the analog output of a turbidity sensor. The digitized turbidity data is transmitted across the galvanic isolation barrier of the ADuM1200 and ADuM5242. The 50 mW of isolated power from the ADuM5242 is sufficient to supply the ADuM1200, the AD7823, and the turbidity sensor. The combined area of the isolators and converter is less than 100 mm², excluding external components.

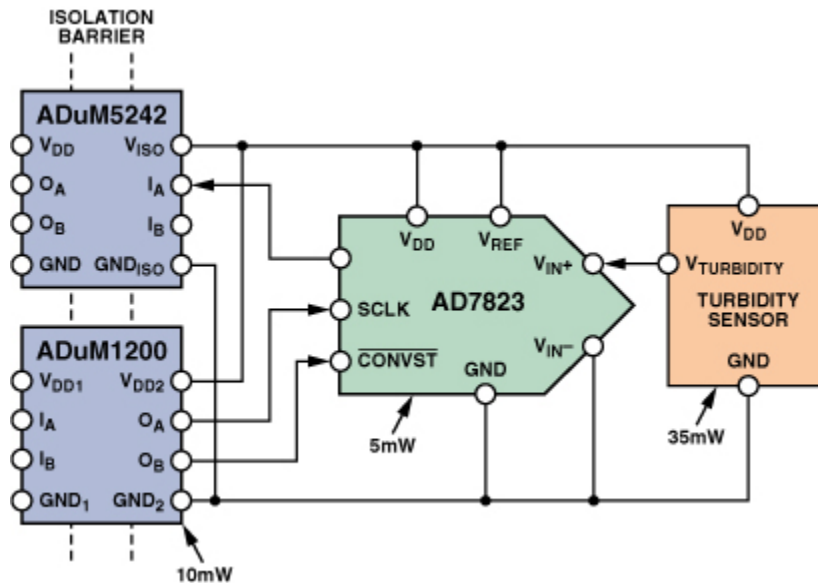


Figure 5. Isolated turbidity sensor.

Bidirectional Isolation

In isolation, the term *bidirectional* has traditionally referred to an isolator with separate *transmit* and *receive* channels in one package—the isolator as a whole is capable of bidirectional data transfer, but the individual channels are unidirectional. This approach is compatible with communications protocols such as RS-232, RS-485, and SPI, but it is not compatible with true bidirectional communication protocols, such as I²C, SMBus, and PMBus, which support bidirectional data transfer through a single channel. Bidirectional and unidirectional isolation are compared in Figure 6.

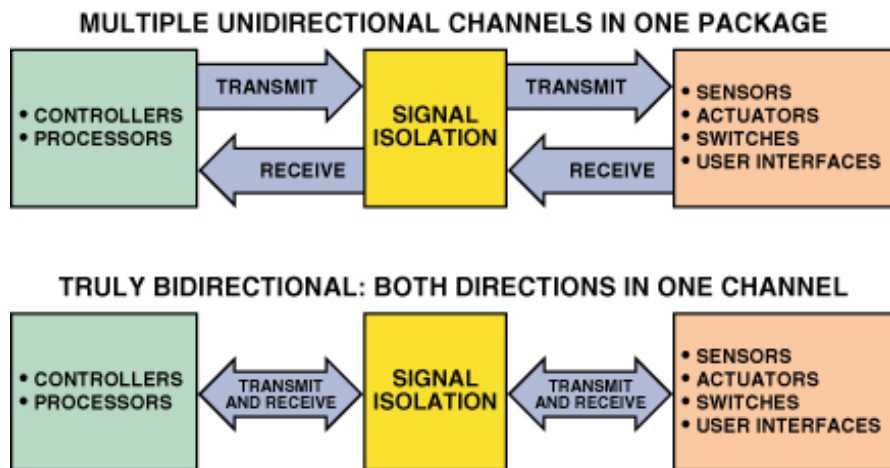


Figure 6. Bidirectional isolation vs. unidirectional isolation.

The inter-integrated-circuit (I²C) bus is a popular 2-wire, bidirectional communication protocol that was developed to provide simple, low-cost, short-distance communication between an on-board controller and its peripherals. I²C buses limit the cost of applications in which multiple devices share a single bus with a host controller, as shown in Figure 7. Two bidirectional wires—one for the data and one for the clock—are used to achieve low cost at the expense of data rate, so I²C is typically used in systems with many peripherals running at data rates less than 1 Mbps. Systems that use a limited number of peripherals running at higher data rates will often employ protocols such as SPI.

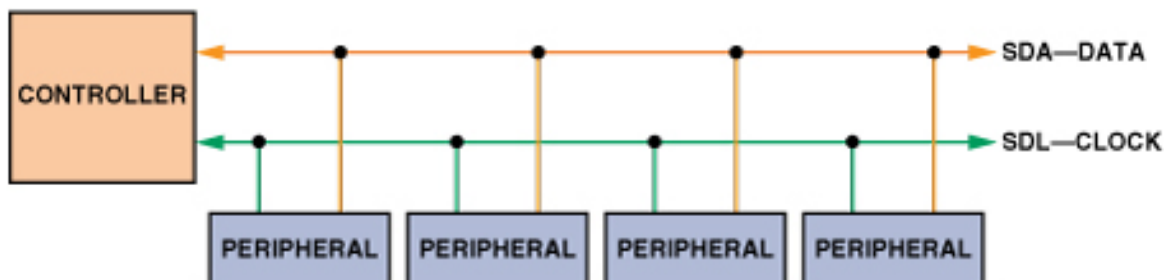


Figure 7. The I²C bus provides communications between host and peripherals.

The I²C isolation challenge has been that optocouplers are based on diodes that can transmit in only one direction, and are therefore inherently unidirectional. A bidirectional I²C bus could be isolated using optocouplers, but the implementation isn't pretty (Figure 8a). A special buffer is used to separate each bidirectional channel into two distinct channels: *transmit* and *receive*. Once separated, the four unidirectional channels can be individually isolated and then recombined. This solution requires four isolators and expands the bus from two wires to four wires. Additional circuitry is also required, making this solution costly and large, and defeating the original purpose of the 2-wire bus implementation: to save money and space.

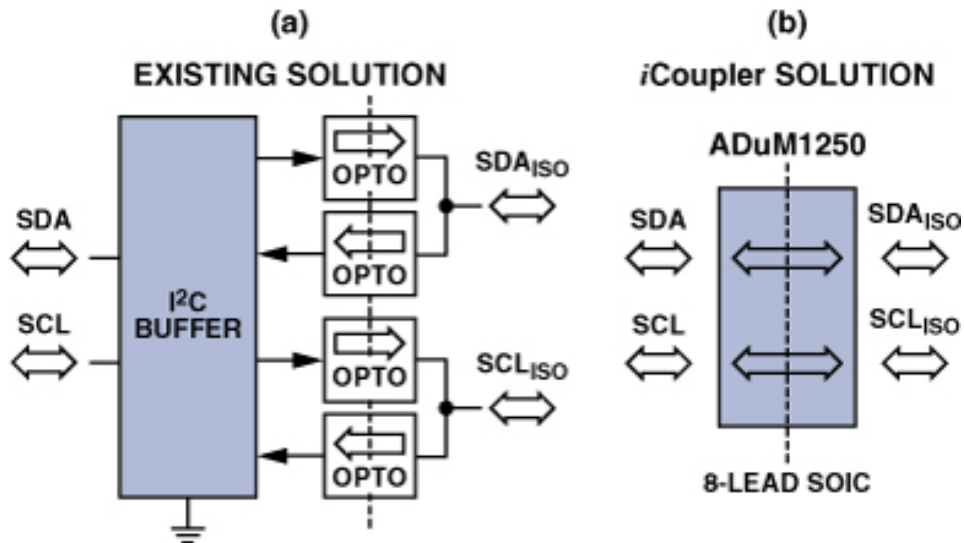


Figure 8. *iCoupler* simplifies bidirectional isolation.

The good news is that by adopting the new digital isolation techniques the circuitry that is used to separate, isolate, and recombine the data channels can be integrated into a single package. This approach can be implemented with the new ADuM1250 and ADuM1251 hot-swappable dual I²C isolators. Figure 8b illustrates how much more compact the *iCoupler* solution is.

Figure 9 shows how bidirectional isolation is achieved within the package. Just as the discrete solution employs a buffer to separate the two bidirectional channels into four unidirectional channels and four isolators, so, too, does the ADuM125x. The difference is that all the electronics are integrated onto a single IC. A designer sees only the 2-wire interface, and the entire device is less than 40 mm², a 90% reduction compared with the optocoupler/buffer solution, which takes up about 350 mm².

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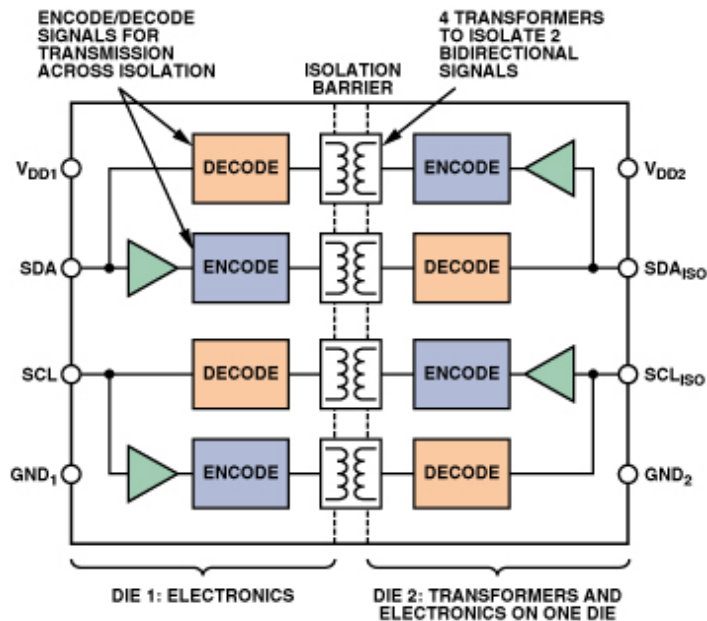


Figure 9. Bidirectional isolation using the ADuM1250.

Future Isolation Solutions

As these examples illustrate, digital isolation continues to offer simplified and novel solutions to challenging design problems. This is achieved at low cost through the use of standard foundry processes that enable integration of features not typically found in classical isolation solutions. In the near future, we can expect to see further advances, with *isoPower* being integrated into an increasing number of isolation applications; and we can also expect to see other novel solutions for isolating buses that are more complex than I²C.

Voluntary Engagement in an Open Web-based Encyclopedia: Wikipedians, and Why They Do It

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University of Wuerzburg

Abstract

The online encyclopedia Wikipedia can be considered as a highly successful *Open Content* project, written and maintained completely by volunteers. Little is known, however, about the motives and interests of these volunteers. Results from an online survey among 106 contributors to the German Wikipedia project are presented. As potential predictors of contributors' engagement and satisfaction, both motives derived from social sciences (e.g., costs-benefits, valence of the Wikipedia goals, identification with Wikipedia, etc.) as well as perceived task characteristics (e.g., task significance, autonomy, skill variety, etc.) were measured. The results reveal that satisfaction ratings of contributors are determined by perceived benefits, identification with the Wikipedia community, and task characteristics. Contributors' engagement (e.g., hours per week) was particularly determined by their tolerance for opportunity costs and the experienced characteristics of their tasks, the latter effect being partially mediated by intrinsic motivation. Most relevant task characteristics both for contributors' engagement and satisfaction were autonomy, task significance, and skill variety. Additional motives reported by Wikipedia contributors suggest the importance of generativity.

Wikipedia is a free online encyclopedia, completely written and maintained by volunteers who collaborate over the Internet (Wikimedia Foundation, 2006). Founded in January 2001, Wikipedia has quickly become one of the 15 most popular websites worldwide (Alexa Inc., 2006) and attracts more than 154 million visitors per month (comScore Networks, 2006). Today, the English Wikipedia contains about 1.5 million articles, followed by the German, French, Polish, Japanese, Dutch, Italian, Portuguese, Swedish, and Spanish Wikipedias with at least 160.000 articles each, and more than 200 smaller projects organized by language or dialect. Despite the huge success of Wikipedia, however, little is known about the motivation of its contributors, usually called *Wikipedians*. As volunteers, many contributors invest a considerable amount of time and endeavor into researching and writing articles, maintaining the technical infrastructure, or participating in community discussions without receiving any financial compensation for their efforts. Moreover, in contrast to other Internet-based voluntary collaboration projects such as Free and Open Source software development (e.g., Hertel, Niedner, & Herrmann, 2003; Moon & Sproull, 2002), Wikipedia has no established public recognition system that might be used as reference in job applications ("credit files"; cf, Voss, 2005; Arazy, Ji & Patterson, 2006). Thus, the question is how to explain the high motivation of

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contributors to Wikipedia. Lessons learned from this successful web-based collaboration project might not only be relevant for other Internet projects based on voluntarism, but also for knowledge sharing systems in commercial business organizations (cf. Majchrzak, Wagner & Yates, 2006).

In the next sections of this paper, we first summarize the main principles of Wikipedia and its relation to similar Internet-based projects; i.e., Free and Open Source Software development. Second, we outline two theoretical models rooting in different research traditions which together provide a theoretical framework for the explanation of contributors' engagement for Wikipedia. The first model builds on research on social movement participation and civic engagement (Klandermans, 1997, 2003; Simon et al., 1998; Stürmer & Simon, 2004) and was already applied in research on Free and Open Source Software development (Hertel et al., 2003). In fact, the Wikipedia project can be understood as a social movement with common goals ("free access to information for everyone"). The second model builds on research explaining task characteristic as antecedents of intrinsic motivation and work satisfaction (Hackman & Oldham, 1975, 1980). Task characteristics and intrinsic motivation might be important factors to explain voluntary engagement in this project because Wikipedia contributors receive neither financial compensation nor explicit public recognition as authors. Both models are not mutually exclusive but complement each other in order to understand the motivational processes in the Wikipedia project.

Wikipedia, Open Content and Open Source Software

The term Wikipedia implies two central properties of the project. First, Wikipedia is technically based on *wiki* software (Leuf & Cunningham, 2001) that enables visitors of a website not only to view web-pages, but also to edit the web-pages easily and instantly, and to add new web-pages. This property is reflected in the term "wiki" which is derived from the Hawaiian word for "quick." Second, the central goal of Wikipedia is the creation of an encyclopedia that is free to use and modify for everyone. As its founder Jimmy Wales has stated in an interview, the vision of Wikipedia is "a world in which every single person on the planet is given free access to the sum of all human knowledge. That's what we're doing." Consequently, Wikipedia is licensed under the GNU Free Documentation License (GFDL; Free Software Foundation, 2002) that requires authors to consent that their contributions to Wikipedia may be used, redistributed, or modified by others as long as the derived content remains free and the original authors are credited.

Each article in Wikipedia can be easily edited by using hyperlinks next to the text, and the changes made are visible immediately. A version history is available for each article along with the real name, user name, or Internet address of the respective author, so that changes can be tracked and reverted easily. Although registered authors might refer to this version history to receive credit for their personal contributions, such references are not as common as in Free and Open Source projects. One reason for this might be that being mentioned in the version history of an article does not indicate the quality of the individual contribution (Voss, 2005).

Moreover, many substantial contributions are made by anonymous authors (Anthony, Smith & Williamson, 2005).

Registered authors can keep a *watchlist* to monitor changes to certain articles, usually those to which they made a contribution themselves. Similarly, a special page lists all *recent changes* to any Wikipedia article. These software features are designed to foster a system of continuous peer-review among contributors and even occasional readers of Wikipedia articles. Research suggests that this system may in fact help to improve the quality of articles and prevent obvious vandalism (Giles, 2005; Viégas, Wattenberg & Kushal, 2004; Anthony et al., 2005; Brändle, 2005).

The quality of articles, however, remains a central concern among contributors to Wikipedia. Quality concerns typically include problems from less obvious errors such as omissions of important facts, biased points of views proposed by certain contributors, or disputes between lay authors and experts such as scientists. In case of disagreements, a fine-grained system of dispute resolutions exists, including a specific discussion page per article, informal or formal mediation, internal opinion surveys, temporarily “freezing” of articles, or blocking users by Wikipedia administrators (i.e., experienced contributors with additional rights).

Wikipedia is often called an *Open Content* project to stress similarities to *Free* or *Open Source Software* (F/OSS) projects such as the Linux operating system, the Mozilla Firefox web browser, or the OpenOffice.org office suit. The source code of these software products is licensed under legal terms (Free Software Foundation, 1991; Open Source Initiative, 2006) that guarantee its availability for possible enhancements in the future. This transparency facilitates a similar process of peer review among F/OSS developers and might lead to more reliable software because “given enough eyeballs, all bugs are shallow” (Raymond, 1999). In order to be effective, however, such a peer review process requires the coordinated efforts of a larger number of volunteers.

Voluntary Participation in Social Movements

Research on social movements such as the civil rights movement has a long tradition in the social sciences (e.g., Della Porta & Diani, 2006; Snyder & Omoto, 2001; Stürmer & Simon, 2004). Social movements can be defined as “collective challenges by people with common purposes and solidarities, in sustained interaction with [others outside the movement]” (Tarrow, 1994, p. 4). Although Wikipedia differs from many traditional social movements because it does not focus on political protest, there are various similarities that might allow the adoption of theoretical models that explain participants’ motivation to contribute. In particular, the vision of free knowledge collected by collective effort and made available to everyone is a common purpose among regular contributors to Wikipedia. Moreover, the voluntary nature of contributions to Wikipedia is another important feature similar to social movements. Due to these structural similarities, we argue that theories of social movement participation may also explain the motivation of contributors to Wikipedia. A similar case has been made for the explanation of successful F/OSS projects (Hertel et al., 2003).

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A recent model that integrates central findings from social movement research was developed by Klandermans (1997, 2003). According to this model, the motivation to participate in a social movement depends on subjective expectancy and importance of several motives, which can be categorized into three classes, as well as identification processes: Elements of the first class, *social motives*, refer to expected reactions of significant others, such as friends, family, or colleagues. More favorable reactions of significant others should lead to a higher motivation to participate. The term “social motives”, however, can be misleading because other motives such as the interest in social contacts and meeting other people are not included in this construct but are considered as individual benefits (Klandermans, 2003). For reasons of clarity, in this paper we will refer to motives related to expected reactions of significant others as *norm-oriented motives*.

Like Klandermans (1997), we will consider social contacts and meeting other people as individual benefits, which are part of the second class of motives. This second class of motives, *individual costs and benefits* (sometimes called selective incentives), include expected gains and losses associated with the voluntary engagement. Losses in the context of voluntary engagement can be direct costs (e.g., donations of money) and opportunity costs (e.g., lack of time for other activities, lack of income because the work is not compensated as in a commercial context). Potential benefits include learning, socializing with others, and meeting other people. The more favorable the expected overall relation of costs and benefits, the higher the motivation to engage in a social movement should be.

Third, collective motives (sometimes called collective incentives) refer to the experienced importance of the common goals of a social movement. The higher the importance of the goals, the higher the motivation to participate should be. The impact of these three classes of motives on the motivation of contributors is often conceptualized as weighted by the subjective expectation that the respective goals will be achieved. Such expectancy models are well established in social sciences (e.g., Finkel & Muller, 1998).

Fourth, social identification processes should complement the three classes of motives and constitute an independent pathway to social movement participation (Klandermans, 2003; Simon et al., 1998; Stürmer & Simon, 2004). When persons feel and categorize themselves as members of a social movement, they are more likely to accept the norms and standards of the movement, resulting in higher motivation to contribute to common goals. Moreover, this pathway should be stronger the longer individuals participate in a social movement. The different components are assumed to contribute additively to the motivation of participants in a social movement.

It should be noted that most other motivational taxonomies discussed in the literature on F/OSS projects are compatible with the Klandermans Model (Clary et al., 1998; Ghosh, 2005; Kollock, 1999; Lerner & Tirole, 2002, 2005). For instance, the economic perspective developed by Lerner and Tirole (2002, 2005) focusing on opportunity costs, career concerns, and ego gratification, might be integrated into the individual costs and benefits component of the Klandermans Model. Similarly, the three dominant types of developers’ motivations proposed

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by Ghosh (2005), social motivations, career or monetary concerns, and political motivations, can be integrated into the costs and benefits component and the collective motives component of the Klandermans Model. In sum, the research on voluntary engagement in social movements and F/OSS suggests that contributors are usually not motivated by altruism, but pursue specific individual interests.

Task Characteristics as Antecedents of Intrinsic Motivation

In addition to extrinsic factors described in the Klandermans Model, a second group of important predictors of voluntary engagement for the Wikipedia project might be based on intrinsic motivation from the activities itself. *Intrinsic motivation* is defined as “the doing of an activity for its inherent satisfaction rather than for some separable consequence. When intrinsically motivated, a person is moved to act for the fun or the challenge entailed rather than because of external [reasons]” (Deci & Ryan, 2000, p. 260). Thus, *interest* and “*having fun*” during an activity are important elements of intrinsic motivation. Moreover, the experience of *competence* when performing a task can be understood as a key component of intrinsic motivation (e.g., Deci & Ryan, 2000). One of the main determinants of the latter is the experience of autonomy in conducting the activity. Finally, the *experience of “flow”* describes a state of absorption when performing a task that is characterized by a distortion of time experience, clear goals, immediate feedback from the activity, focused attention on the activity instead of on the person, a feeling of control, and no concerns about failing at the activity (Csikszentmihalyi, Abuhamdeh & Nakamura, 2005; Waterman, Schwartz, Goldbacher, Green, Miller & Philipp, 2000). Flow usually requires an optimal fit between task and challenges (Csikszentmihalyi et al., 2005). Because higher task-related autonomy allows persons to better adjust tasks to their respective skill levels, we expect a higher chance of flow experiences in self-selected activities.

Interestingly, the three indicators of intrinsic motivation have been already documented in Internet-based Open Source software development projects. “Having fun while programming” is one of the reasons most often mentioned by developers in F/OSS projects both in free format surveys and in open discussion lists (e.g., Torvalds & Diamond, 2001). Moreover, experience of self-efficacy was reported as a significant predictor in collaborative work in F/OSS projects (Hertel et al., 2003). Finally, flow experience and the distortion of time experience is sometimes reported among F/OSS developers (Lakhani & Wolf, 2005). We expect similar effects of intrinsic motivation in the Open Content project Wikipedia.

The Job Characteristics Model (JCM; Hackman & Oldham, 1980) was developed to explain why and how the characteristics of a job or task might influence intrinsic motivation, satisfaction, and performance. Five core characteristics of tasks are considered as relevant in the original model: Skill variety is defined as the extend by which the task requires diverse activities, task identity measures whether a task is completed as a whole from beginning to end and leads to a noticeable result, task significance exists when a task and its outcomes have substantial impact for others, autonomy indicates a worker’s possibility to determine how and when to do the task, and finally, job feedback is provided either from the job itself or from

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other persons, such as colleagues (cf. Hackman & Lawler, 1971). These job characteristics are conceptualized as evoking psychological states in the worker (i.e., experiences of meaningfulness and responsibility, and knowledge of results), that in turn are expected to determine intrinsic motivation, job satisfaction, and work performance. In order to assess their model empirically, Hackman and Oldham (1975) developed the Job Diagnostic Survey (JDS) as a self-report questionnaire instrument that measures individual perceptions of task characteristics, psychological states, and outcomes. The JDS also includes additional scales that refer to contextual factors, such as dealing with others and satisfaction with co-workers, which are not part of the JCM itself but potentially helpful in practice.

Subsequent research has scrutinized the JCM, the JDS, and the interpretation of results collected with the JDS. First, research on the JCM (e.g., Wall, Clegg & Jackson, 1978) found strong associations between the different task characteristics and work outcomes, but only inconclusive evidence for the proposed psychological states. Second, a major problem of the psychometric properties of the JDS is the negative wording in some of the original JDS items, leading to a measurement artifact (Idaszak & Drasgow, 1987). Another problem are the commonly reported substantial zero-order intercorrelations between core task characteristics (Hackman & Oldham, 1980, p. 313; Stone & Gueutal, 1985) that complicate the evaluation of specific consequences of each task characteristic. Third, alternative interpretations of associations between task characteristics and outcomes cannot be rejected based on cross-sectional data (Taber & Taylor, 1990). For example, the social information processing model (cf. Judge, Bono & Locke, 2000) considers individual differences between workers (expectations, standards, etc.) as influences on the perception of task characteristics in addition to objective task characteristics. In spite of these difficulties, the JDS is still a widely used assessment instrument of job characteristics and the meaning of work. It provides useful information about the subjective perceptions of task characteristics (Taber & Taylor, 1990) that are important supplements of more objective or observable task characteristics. In fact, for many psychological processes the subjective experience of work conditions are better predictors than objective measures. Moreover, several strategies are available to compensate for the potential caveats mentioned. For instance, an analytical strategy to handle the substantial zero-order intercorrelations between core task characteristics is to combine ratings of perceived task characteristic into a single score, reflecting the overall motivational potential of the task (e.g., Hackman & Oldham, 1980, p. 313).

Outcomes and Hypotheses

Two measures of Wikipedia participation are investigated as criteria in this study. Both the extent of work engagement (e.g., time spent for Wikipedia) and satisfaction with the engagement as precondition to continue the engagement are expected to be determined by the four components of the Klandermans Model and perceived task characteristics. Volunteers are generally more satisfied if their engagement meets important needs (Clary et al., 1998; Houle, Sagarin & Kaplan, 2005), and Wikipedia contributors in particular should be more satisfied with their engagement if it meets important classes of motives, such as those specified in the Klandermans Model. The relative importance of each component of the model, however,

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depend on the nature and context of social movements (Klandermans, 2003; Stürmer & Simon, 2004). We will first specify the expected effects of each component of the Klandermans Model, and then discuss effects of task characteristics on engagement and satisfaction.

Hypotheses based on the Klandermans Model of social movement participation

Research on voluntary engagement in social movements and F/OSS suggests that contributors are usually not altruists, but pursue specific individual interests. We expect similar processes in the Wikipedia project, assuming that the perceived relation of costs vs. benefits is positively related to both engagement and satisfaction:

Hypothesis 1: A positive net value of individual costs and benefits is positively associated with the extent of contributors' engagement for Wikipedia.

Hypothesis 2: A positive net value of individual costs and benefits is positively associated with contributors' satisfaction with their engagement for Wikipedia.

Second, identification is an important motivational factor for volunteers in general (Stürmer & Simon, 2004) and for F/OSS developers in particular (Hertel et al., 2003; Lakhani & Wolf, 2005). Contributors to Wikipedia call themselves *Wikipedians* and often express their affiliation with the Wikipedia community on mailing lists or user pages, suggesting social identification processes. Such identification with the Wikipedia community is expected to be positively associated with engagement and satisfaction:

Hypothesis 3: Identification with the Wikipedia community is positively associated with the extent of contributors' engagement.

Hypothesis 4: Identification with the Wikipedia community is positively associated contributors' satisfaction with their engagement.

The two remaining components of the Klandermans Model, norm-oriented motives and collective motives, are important factors in social or political movements (e.g., Simon et al., 2003) but are considered as less relevant in research on F/OSS projects. For instance, Ghosh (2005) identified only 13% of developers as primarily motivated by political motives, and only one third of developers surveyed by Lakhani and Wolf (2005) considered collective motives important at all. This lower importance of collective and normative motives might be due to the fact that F/OSS developers, unlike participants in other social movements, do not belong to a disadvantaged minority in society or have to face serious risks (e.g., violent acts of political opponents, loss of social support by relevant others) when participating in F/OSS development. In a similar way, we expect that norm-oriented and collective motives show weaker effects on the engagement and satisfaction of Wikipedia contributors than expected costs and benefits and identification:

Hypothesis 5: Norm-oriented motives and collective motives are less strongly associated with Wikipedia contributors' engagement compared to perceived costs and benefits and identification.

Hypothesis 6: Norm-oriented motives and collective motives are less strongly associated with Wikipedia contributors' satisfaction with their engagement compared to perceived costs and benefits and identification.

Hypotheses based on the Job Characteristics Model

Task characteristics have been studied in a wide range of industries, including commercial software development (Couger & Zawacki, 1980; Thatcher, Stepina & Boyle, 2002). However, task features have not been explored in research on voluntary engagement in web-based collaboration so far. We expect that the perceived task characteristics predict satisfaction, intrinsic motivation, and engagement of Wikipedia contributors in a similar way as in other work environments. Based on an action-theoretical perspective of behavior (Heckhausen & Gollwitzer, 1987), we expect that a higher perceived quality of task characteristics leads to higher intrinsic motivation, which in turn leads to higher engagement:

Hypothesis 7: The perceived quality of task characteristics positively affects the extend of engagement for Wikipedia, and this effect is mediated by intrinsic motivation.

Hypothesis 8: The perceived quality of task characteristics positively affects satisfaction with the engagement for Wikipedia.

Considering the relative impact of the specific task characteristics, we expect autonomy, task significance, and skill variety as most important determinants of the composite variable of participants' task experience. Autonomy enables both experiences of flow (Csikszentmihalyi, Abuhamdeh & Nakamura, 2005) and competence (Deci & Ryan, 2000). Task significance should affect the overall task experience of Wikipedia contributors due to the public-utility goals of Wikipedia (e.g., Wikipedia can be used by millions of readers for free). Feedback from others should be an important factor because writing articles for Wikipedia heavily relies on peer review processes. In one initial study on civic engagement (Wehner & Güntert, 2005), feedback has been documented as important for the task experience during voluntary work, such as youth work, sports clubs, cultural committees, and welfare work. In addition, skill variety might be important because Wikipedia contributors can select and tailor their activities to their diverse interests and skills. Together, we expect:

Hypothesis 9: Perceived autonomy, task significance, and feedback most strongly determine the overall task experience of contributors to Wikipedia.

Methods

A web-based questionnaire survey was conducted among contributors to the German version of Wikipedia measuring the components of the Klandermans Model and perceived task characteristics as predictors, intrinsic motivation as mediator, and engagement as well as satisfaction with the engagement as criteria variables. Moreover, open questions for additional motives were included apart from demographic variables for exploratory reasons.

Data Collection and Participants

Participants were invited over the mailing list of the German Wikipedia project. We also asked subscribers to the mailing list to forward our invitation to other contributors who would not read the mailing list, and link to the survey from suitable web sites. A total of $N = 106$ contributors participated in our survey. Eighty-eight percent of these participants were male, 10 percent were female, and 2 percent did not specify their sex. The mean age was 33 years ($SD = 12$ years, range from 16 to 70 years). The majority of participants worked full-time (43%) or part-time (10%), whereas 5% were unemployed. Another large group were university students (26%) or high-school students (6%). The remaining participants reported a different employment status, such as retirement. At the time of the survey, participants had been engaged in the Wikipedia project for 16 months on average ($SD = 10$, range from 1 to 48 months), and had used the Internet for 92 months on average ($SD = 33$, range from 12 to 180 months). Most of the participants categorized themselves as authors (86%), and more than a third (37%) also had at least administrator rights. Only 4% were engaged in the development or translation of software for Wikipedia, but more than a quarter (27%) of the participants reported to be engaged in one or more F/OSS projects, such as Linux (11%), Mozilla (9%), or OpenOffice.org (7%).

Measures and Questionnaire Design

Predictors based on the Klandermans Model of social movement participation

Items measuring the components of the Klandermans Model were mainly adopted from Hertel et al. (2003) and translated into German. The *norm-oriented motive* component was measured by only one item asking participants about attitudes of relevant others (family, friends, or colleagues) towards their engagement for Wikipedia. The measure of the *individual costs and benefits component* contained five items. Participants rated the importance of two potential benefits (learning and job/school qualification,) as well as two aspects of opportunity costs, (time loss and as lack of payment) due to the engagement in Wikipedia. Contributors also indicated how they judged the relation of effort to the benefits from their engagement for Wikipedia. Such a “selfishness” measure (Ghosh, 2005, p. 33) allows for a wider range of individual costs and benefits which might not be covered by the specific items above, and has proven informative in research on the motivation of F/OSS developers. The *collective motive* component was measured by participants’ ratings how important central goals of the Wikipedia community project were to them: improving the quality of Wikipedia as a whole, and the belief that information should be free. Finally, the *identification* component was measured using three

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items referring to identification with the Wikipedia project, feeling proud to be a Wikipedian, and self-description as a typical Wikipedian (Doosje, Elemers & Spears, 1995). All items were measured on seven-point Likert scales.

Perceived task characteristics

Perceived characteristics for skill variety, task identity, task significance, autonomy, feedback from others were measured using items from the German version of the Job Diagnostic Survey (Schmidt & Kleinbeck, 1999). Only single item-measures with positive wording and were selected from the JDS to reduce method-specific variance for task identity, task significance, autonomy and feedback from others. Two items were used to measure skill variety. Feedback from others was included instead of feedback from the job itself because the continuous peer-review process in Wikipedia largely depends on interactions with others. Finally, dealing with others was included as a context factor to supplement core task characteristics, and measured by two items. All task characteristics were measured using seven-point Likert scales.

Intrinsic motivation

Experienced competence was measured using three items adapted and translated from an intrinsic motivation scale by Warr, Cook, and Wall (1979) to reflect cognitive, affective, and behavioral aspects of this construct. *Task enjoyment* was measured using three items mainly adapted and extended from Hertel et al. (2003), and referred to fun from writing articles, fun from reviewing articles, as well as the relation of fun versus strain (“fun outweighs the effort”). Finally, a single item-measure was used to measure the experienced distortion of time as a key component of flow experience (Lakhani & Wolf, 2005). Because this item only reflects a part of the flow construct, we will refer to this item as *experienced time distortion* throughout this paper. Again, all items were measured using seven-point Likert scales.

Engagement

Current engagement was measured by three items. Participants were asked to indicate the time spent per day for Wikipedia-related activities both during leisure time and at work in two open questions to improve data quality (cf. Tourangeau, Lips, & Rasinski, 2000). They were also asked to specify the number of articles on their watchlists (if any) as a proxy for the number of articles they contributed to or were involved in.

Satisfaction with Wikipedia engagement

Items from three subscales of the JDS were used to assess facets of satisfaction with the engagement in Wikipedia. *General satisfaction with Wikipedia engagement* was measured using two items, whereas *growth satisfaction* was measured using four items because it might be an especially relevant subscale in volunteer work. Similarly, *satisfaction with co-workers* as a potentially relevant context variable was assessed using four items. Wording was adapted to

fit the context of Wikipedia engagement, and all items were measured using seven-point Likert scales.

Demographic data and further motives

Finally, demographic data about participants was collected, including sex, age and nationality. Participants were also asked to report further motives for their engagement that were not covered in the survey using an open question at the end of the questionnaire.

Statistical Approach Partial Least Squares path modeling

Data analyses were conducted using the *Partial Least Squares* (PLS; e.g., Jöreskog & Wold, 1982; Anderson & Gerbing, 1988; Fornell & Cha, 1994) path modeling algorithm. The PLS algorithm estimates path models using composite variables, sometimes called latent variables, from a number of indicator items, sometimes called manifest variables. In this respect, the variance-based PLS path modeling is similar to covariance based structural equation modeling (SEM, e.g. using LISREL, Jöreskog & Sörbom, 2003) because both algorithms estimate complex relations between several latent variables simultaneously. Nevertheless, a number of conceptual and formal differences (cf. Chin & Newsted, 1999) make PLS path modeling especially suited for this study. Compared to covariance-based SEM, the PLS path modeling algorithm can be used with smaller samples, requires fewer assumptions about data distributions, is robust in case these assumptions are violated (Cassel, Hackl & Westlund, 1999), and can be used with more complex models containing a larger number of composite variables.. It does not, however, compute a single index of model fit, such as the GFI or RMSEA in covariance-based SEM. PLS path modeling focuses on prediction whereas covariance-based SEM is more often used for theory testing by comparing the relative fit of several theoretical models to the data. Furthermore, in PLS path modeling, individual scores for composite variables are estimated and available for subsequent data analyses, such as mediation analyses (e.g. Baron & Kenny, 1986). This is not possible in covariance-based SEM because of factor indeterminacy.

Regardless of the estimation algorithm, an important distinction needs to be made between *reflective* and *formative indicators* in structural equation modeling (Bollen & Lennox, 1991; MacKenzie, Podsakoff & Jarvis, 2005). Reflective indicators can be understood as being determined by, or to reflect, an underlying composite latent variable (graphically represented as an arrow from the latent variable to the indicator). Formative indicators are used to jointly form or cause the composite latent variable (graphically represented as an arrow from the indicator to the latent variable), i.e., indicators are understood as defining characteristics of the latent component variable. Psychological instruments usually employ reflective indicators because they rely on classical test theory (Bollen & Lennox, 1991). Reflective indicators are, however, not appropriate in many cases, especially when the constructs explored are conceptually heterogeneous and multi-dimensional. For example, job satisfaction is often conceptualized as a combination of a number of distinct facets (satisfaction with payment, supervision, coworkers,

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etc.), and overall job satisfaction of a person is constituted only by all these indicators as a group. In a similar way, the overall balance of expected costs and benefits is only constituted by all costs and benefits together and should not be conceptualized to reflect an underlying true score (cf. Simon et al, 1998). Usually the term *scale* refers to a composite latent variable based on reflective indicators, whereas the term *index* refers to a composite latent variable based on formative indicators. Weights are based on zero-order correlation coefficients or factor loadings for reflective indicators, but on multiple regression coefficients for formative indicators.

As McKenzie, Podsakoff, and Jarvis (2005) note, “the distinction between reflective- and formative-indicator models can be generalized to higher order factor structures.” For example, even if several first-order constructs related to intrinsic motivation (such as enjoyment or experienced competence) might represent distinct dimensions of this construct, they are likely to overlap and share common variance. In PLS path modeling, *second-order constructs* can be integrated using a two-step procedure. Case values for each first-order construct can be estimated in separate models (Wold, 1982, p. 40), and then be integrated as indicators of a second-order construct in the complete model.

Model specification

A path model was developed based on the Klandermans Model of social movement participation and the Job Characteristics Model to test the relative predictive power of the proposed factors (*norm-oriented motives, reward motives, collective motives, identification, and task characteristics*) on satisfaction and engagement for Wikipedia. With regard to the measurement models, only identification was conceptualized as a reflective measure because items were adopted from a scale designed to reflect an underlying true score of identification. All other predictors were conceptualized as formative because their respective manifest variables were supposed to jointly constitute the constructs instead of reflecting an underlying true score. For example, no single underlying true score or homogeneous loadings may be assumed for the costs and benefits component of the Klandermans Model because the overall relation is only defined by a combination of several costs and benefits.

Although empirical research confirms the discriminative validity of different aspects of intrinsic motivation (cf. Waterman, Schwartz, Goldbacher, Green, Miller & Philip, 2003), their respective measures usually correlate considerably. To avoid instable parameter estimates due to multicollinearity, experience of flow, enjoyment, and experienced competence were conceptualized as first-order factors forming a second-order factor of intrinsic motivation. Case values for first-order factors were estimated in a separate model, and then used as manifest variables of a more global composite latent variable representing *intrinsic motivation* in the complete model.

Similarly, general satisfaction with Wikipedia engagement, growth satisfaction, and satisfaction with others were conceptualized as forming a second-order factor of *satisfaction*. Again, case values were estimated in a separate model and then used as manifest variables in the complete

model. The extend of engagement in Wikipedia was conceptualized as an index constituted both by measures of time spent for Wikipedia and articles on contributors' watchlists.

Results

Data analyses were conducted with SmartPLS 2.0 (Ringle, Wende, & Will, 2006) and missing values were replaced by means. Sample size ($N = 106$) was adequate for conducting a PLS analysis, meeting both the necessary observation to indicator ratio heuristic (at least 10:1 for the formative composite latent variable with the largest number of indicators), and the path to indicator ratio heuristic (at least 10:1 for the endogenous with the largest number of connected exogenous variables) proposed by Chin and Newsted (1999). It should be noted, however, that the relatively small sample size in the present study limits the statistical power to detect small effects of single predictors in the structural model in the presence of all remaining predictors. Cohen (1988) suggests to interpret values of $f^2 = 0.02, 0.15,$ and 0.35 as small, medium, and large effects. Because PLS path estimates are based on regression analyses, effect sizes of single predictors can be obtained by comparing the explained amount of variance when a predictor is either included or not included in the model ($f^2 = (R^2_{incl} - R^2_{excl}) / (1 - R^2_{incl})$; Cohen, 1988, p. 410).

PLS Path Model Measurement model

Although PLS does not require rigid distributional assumptions for estimation and optimization, normality is desirable for statistical inferences (Marcoulides & Saunders, 2006). Following a data screening, the number of articles on participants' watchlists was ln-transformed because of its skewed distribution. Following that procedure, no indicator in the measurement model exceeded the critical values for skewness or kurtosis suggested by Curran, West and Finch (1996). Means and standard deviations are reported in Table 1.

Table 1
Descriptives, Loadings, Outer Weights and Variance Inflation of Manifest Variables in the Measurement Model.

Items	Loading Weight				
	<i>M</i>	<i>SD</i>	r_{ij}	w_{ij}	VIF
Norm-related Motives					
Relevant others	4.10	1.51	1.00	1.00	1.00
Costs and Benefits					
Benefits exceed costs	4.53	1.74	.86***	.77***	1.10
Job / school qualification	3.76	1.90	.33 [†]	.18	1.04
Learning	5.84	1.17	.45*	.31 [†]	1.11
Loss of time	4.44	1.34	-.31	-.27	1.05
Unpaid work	3.10	1.96	-.19	-.28	1.05

Collective Motives					
Freedom of information	6.20	1.25	.99***	1.01***	1.02
Quality improvement	6.36	0.93	.02	-.12	1.02
Identification (reflective)					
Community	5.13	1.40	.88***	.46***	
Pride	5.04	1.67	.87***	.46***	
Typical Wikipedian	4.41	1.49	.72***	.27***	
Task characteristics					
Skill variety ^c	4.64	1.31	.51**	.40*	1.16
Task identity	4.61	1.36	.30 [†]	.20	1.05
Task significance	4.15	1.50	.76***	.46**	1.34
Autonomy	5.56	1.15	.71***	.51**	1.21
Feedback from others	3.45	1.55	.51**	.02	1.42
Dealing with others ^c	4.18	1.50	.28 [†]	.05	1.18
Intrinsic Motivation ^b					
Time distortion	5.66	1.36	.84***	.75***	1.04
Enjoyment ^a	5.45	0.87	.57***	.28	1.20
Experienced competence ^a	5.44	0.84	.56**	.37 [†]	1.17
Satisfaction ^b					
Growth satisfaction ^a	5.53	0.87	.98***	.86***	1.45
General satisfaction ^a	5.49	1.11	.53***	.05	1.32
Satisfaction with others ^a	4.91	1.06	.59**	.23	1.22
Engagement					
Leisure time / day	114 min.	93 min.	.87***	.64**	1.23
Working time / day	23 min.	28 min.	.48 [†]	.22	1.09
Articles on watchlist (ln)	5.33	1.54	.75**	.45*	1.20

Notes. ^aFirst-order composite latent variable. ^bSecond-order composite latent variable.

^cAggregate value. The variance inflation factor (VIF) is only relevant for indicators in formative measurement models.

[†] $p < .05$, one-tailed. * $p < .05$, two-tailed. ** $p < .01$, two-tailed. *** $p < .001$, two-tailed.

Different indicators are used to assess the quality and utility of reflective and formative composite latent variables. Indicators in reflective measurement models can be assessed using common quality criteria such as coefficient alpha, composite reliability (CR), or the average variance extracted (AVE; Fornell & Larcker, 1981) which should exceed the .50 threshold. The only composite latent variable with a formative measurement model in our analysis was identification, and quality criteria were satisfactory (coefficient alpha = .77, CR = .87, AVE = .69). For assessing indicators in formative measurement models, different quality criteria are required. Because excessive multicollinearity of indicators makes it difficult to separate the influence of several indicators on the composite latent variable (Bollen & Lennox, 1991), the variance inflation factor (VIF) of each indicator should be close to 1. As Table 1 shows, VIFs in the measurement models varied between 1.02 and 1.45. In general, these results suggest that

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multicollinearity between indicators is not a major problem in this study. Specific model-dependent cutoff-values (Craney & Surlis, 2002), however, suggest that low weights of indicators of task characteristics with a VIF above 1.34 should be interpreted with caution. Table 2 reports descriptives and zero-order correlations for the resulting composite latent variables.

Table 2
Descriptives and Zero-Order Correlations Between Latent Variables in the Structural Model

	M_a	SD_a	1	2	3	4	5	6	7
1 Norms	4.10	1.51							
2 Costs and Benefits	4.64	0.86	.15						
3 Collective Motives	6.17	1.51	.07	.26**					
4 Identification	4.87	1.28	.23*	.14	.35**				
5 Task Characteristics	4.63	0.75	.17†	.07	.24*	.34* **			
6 Intrinsic Motivation ^b			.25**	.06	.31***	.46* **	.42* **		
7 Satisfaction ^b			.30**	.38***	.39***	.48* **	.66* **	.40* **	
8 Engagement			.15	-.28**	-.01	.23*	.32* *	.34* **	.16

Notes. ^a Although all calculations were conducted using z-standardized measures, unstandardized means and standard deviations are reported in the original metric for easier interpretation. These descriptives were re-constructed from original data based on results from the PLS analysis. Only means and standard deviations for first-order composite latent variables based on Likert-type manifest variables are reported. ^b Second order composite latent variable.

† $p < .05$, one-tailed. * $p < .05$, two-tailed. ** $p < .01$, two-tailed. *** $p \leq .001$, two-tailed.

Structural model

The structural model was evaluated on the basis of R^2 for each endogenous composite latent variable, structural paths, and effect sizes of exogenous composite latent variables. The stability and statistical significance of the structural path estimates were assessed using the bootstrapping resampling method (with $N = 106$ cases, 1000 resamples and individual sign changes; cf. Tenenhaus, Vinzi, Chatelin & Lauro, 2005).

As shown in Figure 1, exogenous variables in the model explained substantial amounts of variance of satisfaction ($R^2 = .62$) and engagement ($R^2 = .28$), and at least some variance of intrinsic motivation ($R^2 = .17$).

Figure 1. PLS path analytic model: Influence of predictors from the the Klandermans Model of social movement participation, task characteristics, and intrinsic motivation on satisfaction and engagement. To allow for additional effects of intrinsic motivation not specified in the hypotheses, an additional path from intrinsic motivation to satisfaction was included in the model. Bootstrapped *t*-values are listed in brackets below path coefficients.

† $p < .05$, one-tailed. * $p < .05$, two-tailed. ** $p < .01$, two-tailed. *** $p < .001$, two-tailed.

For the satisfaction ratings, the components of the Klandermans Model together accounted for a partial $R^2 = .27$, or 44% of the total explained variance in the composite latent variable (cf. Table 3). More specifically, significant predictors of satisfaction among these components included costs and benefits ($\beta = .26$, $p < .05$, $f^2 = .16$) and identification with Wikipedia ($\beta = .19$, $p < .05$, $f^2 = .07$), consistent with Hypotheses 2 and 4. Although lower in effect size, norm-oriented motives were also significant ($\beta = .12$, $p < .05$ for a directional test), whereas collective motives failed to reach significance. As expected in Hypothesis 6, the combined effect of norm-oriented and collective motives was smaller ($f^2 = .04$) in comparison to cost-benefit considerations and identification. Moreover, perceived task characteristics explained a major part of the variance in satisfaction ratings ($\beta = .52$, $p < .001$, $f^2 = .54$), as was expected in Hypothesis 8.

For the measured engagement of Wikipedia contributors, the four components of the Klandermans Model together accounted for a partial $R^2 = .13$, or 46%, of the total explained variance. However, the only significant predictor of engagement among these components was the costs-benefits index, and this relation was negative rather than positive ($\beta = -.31$, $p < .05$, $f^2 = .12$). These results are surprising in two ways. First, the negative relation of the costs-benefits component contradicts Hypothesis 1, as well as the majority of results from research on the motivation of F/OSS developers (e.g., Ghosh, 2005; Hertel et al., 2003). The cross-sectional design of this survey, however, does not allow a causal interpretation of this association. Very active contributors might be simply more likely to experience opportunity costs, such as lack of time for other activities, that result in a more unfavorable relation of costs and benefits.

Second, contrary to Hypothesis 3 the effect of identification on engagement failed to reach significance, despite its significant and positive zero-order correlation reported in Table 2. This might be due to the limited statistical power in the present study. With respect to the remaining components of the Klandermans Model, and consistent with Hypothesis 5, neither norm-oriented motives nor collective motives were significant predictors of engagement, and their combined effect was small ($f^2 = .02$).

Table 3

Unique Variance Components (partial R^2) of Satisfaction and Engagement Accounted For by Components of the Klandermans Model, Task Characteristics, and Intrinsic Motivation.

Satisfaction ($R^2 = .62$)		Engagement ($R^2 = .28$)	
R^2_{part}	% R^2	R^2_{part}	% R^2

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Social Norms	.04	6	.01	4
Costs and Benefits	.10	16	.09	31
Collective Motives	.04	7	.00	0
Identification	.09	15	.03	10
Task Characteristics ^a	.35	56	.07	26
Intrinsic Motivation	.00	0	.08	28

Notes. ^a Only direct effects of task characteristics are reported here because partial R^2 is based on direct path coefficients and zero-order correlations. Deviations of summed percentages from 100% are due to rounding errors.

Finally, the direct effect of perceived task characteristics on engagement failed to reach significance ($\beta = .22, p = .11$) despite the medium-sized and significant zero-order correlation reported in Table 2. Perceived task characteristics, however, had a medium-sized effect on intrinsic motivation ($\beta = .41, p < .001, f^2 = .21$), which in turn had a small to medium-sized effect on engagement ($\beta = .23, p < .05$ for a directional test, $f^2 = .06$). Intrinsic motivation alone accounted for a partial $R^2 = .08$, or 28% of the explained variance of the engagement measure, revealing the expected importance of intrinsic motivation for Wikipedia engagement. Even though these findings already suggest a mediating effect of intrinsic motivation (Hypothesis 7), a more formal test was conducted in a separate follow-up analysis.

Mediation Analysis

To test Hypothesis 7 proposing that intrinsic motivation mediates the effect of task characteristics on engagement for Wikipedia, a mediation analysis was conducted with case values of composite latent variables obtained in the PLS analysis. Using the bootstrap procedure provided by Preacher and Hayes (2004) and following the steps suggested by Baron and Kenny (1986 ; cf. Shrout & Bolger, 2002), the bivariate regression of engagement on task characteristics was significant ($\beta = .32, p = .001$). Second, perceived task characteristics were a significant predictor of intrinsic motivation ($\beta = .42, p < .001$; see above). Third, the effect of intrinsic motivation on engagement when controlling for perceived task characteristics was significant ($\beta = .25, p = .02$). Finally, the effect of task characteristics when controlling for intrinsic motivation was clearly reduced but still significant ($\beta = .21, p < .05$), indicating partial mediation. The Sobel test of this mediation was significant ($z = 2.15, p < .05$) and confirms Hypothesis 7 that intrinsic motivation (partially) mediates effects of perceived task characteristics on the reported engagement of Wikipedia contributors.

Item-Level Analyses of Perceived Task Characteristics

In order to explore which of the task characteristics most strongly affected the task experience of the participating Wikipedia contributors, the measurement model of perceived task characteristics as reported in Table 1 was analyzed in more detail. Due to its conceptualization as a formative model, interpretation of the model should be based on weights instead of

loadings as long as multicollinearity is low. Weights were significant for autonomy ($w = .51$), task significance ($w = .46$), and skill variety ($w = .40$). All other weights failed to reach significance.

The negligible weight of feedback from others ($w = .02$), however, was due to multicollinearity among manifest variables. Because its VIF of 1.42 exceeded the model-dependent critical value of 1.34, its high loading marked this manifest variable as reflective of the construct measured by the composite latent variable (Bagozzi, Fornell & Larcker, 1981; Diamantopoulos & Winklhofer, 2001). Moreover, dealing with others did not contribute significantly to the overall perception of task characteristics despite the highly interactive nature of Wikipedia. In sum, the results support the higher importance of autonomy and task significance compared to the remaining task characteristics, consistent with Hypothesis 9.

Further Motives Reported By Wikipedia Contributors

Based on the additional open format questions, an inductive content analysis was conducted to analyze further motives reported by Wikipedia contributors. A total of 44 statements were identified and categorized into nine categories ($\kappa = .87$) by two raters. The most frequently mentioned category was *task enjoyment*, which contained 9 statements (20%), for instance “I like working with text” or “I enjoy writing.” Since task enjoyment is part of the intrinsic motivation construct, this result further underlines the importance of task-related motives for Wikipedia engagement. A second category was labeled *sharing information*, summarizing statements such as “power to share knowledge” or “cover topics that are omitted in other encyclopedias.” This category contained five statements (11%) and resembles the collective motives component of the Klandermans Model, suggesting that collective motives also play a role for the Wikipedia engagement. Please note that collective motives also yielded the highest mean values in the survey despite their non-significant effects in the path model. We will address these findings further in the discussion section. A third category included statements such as “create a heritage for our children” or “timeless project to collect knowledge” and was labeled *generativity*. This category also contained five statements (11%). The fourth category was labeled *growth and self-enhancement* with statements such as “compensation for unrealized career aspirations” and “gaining knowledge for further projects” (four statements or 9%). The fifth and sixth categories with three statements (7%) each, were labeled as *community-related motives* or *interest in the project*. Two statements (5%) were categorized as referring to *useful leisure activities* as the seventh category. Six statements (14%) were categorized as *specific motives* including such diverse statements such as “if I won’t do it, who else will?”, “vanity”, “sense of order”, or references to F/OSS principles. Finally, a ninth category was labeled as *dissatisfaction* and contained seven statements (16%) that could be reasons for contributors to terminate their engagement. These statements included “vandalism”, “excessive discussions with trouble-makers or extremists”, “blockings of users”, or “bad server performance.”

Whereas the task enjoyment and sharing information categories overlap with motives already considered systematically in our survey, the third category (generativity) refers to aspects

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developed in life-span psychology (e.g., McAdams & de St. Aubin, 1992). Interestingly, statements from this category were as frequently mentioned as statements related to sharing information, suggesting that generativity might be another important motive for contributors to Wikipedia. Although related to the need for efficacy proposed as explanation of participation in online communities (Kollock, 1999), this generativity motive goes beyond mere individualistic motives and contains also a societal dimension.

For exploratory reasons, we calculated nonparametric correlations between the dummy-coded categories and motivational factors in the survey for those contributors who specified additional motives ($n = 34$). Four of these correlations were significant ($p < .05$). The generativity category was positively related to identification ($\tau = .29$) and perceived task characteristics ($\tau = .35$), whereas the dissatisfaction category was negatively related to perceived task characteristics ($\tau = -.29$) and engagement ($\tau = -.35$). These findings might suggest that the task characteristics of Wikipedia engagement potentially facilitate the fulfillment of generativity motives, whereas dissatisfaction due to diverse problems is associated with decreasing engagement.

Discussion

This study explored the motivation of Wikipedia contributors by integrating models from social sciences and from work psychology. Whereas the Klandermans Model of social movement participation (Klandermans, 1997, 2003; Stürmer & Simon, 2004) covered influences of norm-oriented motives, individual costs and benefits, collective motives, and identification with Wikipedia, the Job Characteristic Model (Hackman & Oldham, 1975, 1980) covered the influences of perceived task characteristics and intrinsic motivation both on engagement and on satisfaction with the engagement for Wikipedia. Moreover, additional motives reported by Wikipedia contributors were collected in an open format.

Results supported our research model to a large extent. As expected, satisfaction with the engagement for Wikipedia was determined by the net balance between costs and benefits, by the identification with the Wikipedia community, and by perceived task characteristics. Contrary to our expectations, however, the relation between the net balance of costs and benefits and the reported engagement was negative rather than positive. An explanation might be the lack of external incentives in the case of Wikipedia, leading to a less favorable evaluation of costs and benefits, and requiring a high tolerance for opportunity costs for contributors. On the other hand, and again consistent with our expectations, the engagement reported by Wikipedia contributors was positively related to intrinsic motivation, which partially mediated the effect of perceived task characteristics on engagement. Among the perceived task characteristics, task autonomy, significance of the activity, and skill variety contributed most strongly to the overall task experience in Wikipedia engagement (see Wehner & Güntert, 2005, for similar results in the context of volunteer civic engagement). The effect of feedback from others on the overall task experience was largely attenuated by multicollinearity among task characteristics. Moreover, personal feedback might be more prominent in volunteer activities involving direct face-to-face interactions (e.g., youth work) than in the computer-mediated collaboration for

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Wikipedia. Finally, the three most prominent categories of additional motives mentioned by Wikipedia contributors in the open questions were related to task enjoyment, information sharing, and generativity motives.

Building on research on the motivation of F/OSS developers, we could determine similarities and differences between the motivation of contributors to Open Source projects and Wikipedia. Although structural similarities (peer review process, free license, political background, etc.) exist, and some of the participants contribute both to F/OSS projects and Wikipedia, other motivational processes seem to differ. Most notably, F/OSS projects provide clear individual incentives for contributors such as better software for personal use, career advantages etc. (Gosh, 2005; Hertel et al., 2003; Lerner & Tirole, 2002) whereas corresponding incentives are much lower or lacking completely for Wikipedia contributors. This is reflected in the negative relation between individual costs and benefits and engagement that is in contrast to findings in F/OSS projects. In this respect, Wikipedia is an even more extreme example of voluntary engagement in Internet-based projects. Highly engaged Wikipedians must have a high tolerance for experienced opportunity costs, but the activity itself might counter this effect by providing other (intrinsic) incentives. Methodological reasons, however, might also help to explain the difference between this result and findings in F/OSS projects. For example, it is possible that only few contributors report an unfavorable net balance of costs and benefits, but that these contributors are those who contribute most. In this case, purely descriptive analyses could be misleading.

Nevertheless, descriptive analyses supplement regression based analyses. In the present study, the collective motives class of the Klandermans Model was no significant predictor in the path model but clearly yielded the highest mean of all components (cf. Tables 1 and 2). Apart from potential ceiling effects, this result might point to a threshold process in which potential contributors first have to agree with the general goals of Wikipedia (as measured by collective motives) in order to participate at all. However, this first agreement does not predict the degree of later engagement or satisfaction.

In the future, longitudinal research would allow to determine the role and interactions of different components of the Klandermans Model including collective motives at different stages of Wikipedia engagement. For example, perceived costs and benefits might be more important in the beginning of Wikipedia activities whereas identification might become more important at later stages (cf. Gosh, 2005, and Finkel & Muller, 1998 for related results for F/OSS and political movement participation). Several repeated measurements could also reduce the influence of common-method bias that might be present in cross-sectional research.

The sample characteristics of the present study might be another limitation because participants were very involved in Wikipedia. For instance, the average time spent on Wikipedia engagement per day ($M = 133$ minutes) and the number of administrators in the sample (37%) was quite high.⁴ Thus, the reported results might not be the same for occasional contributors to Wikipedia. Although the quality of contributions from occasional authors is sometimes very

high (Anthony, Smith & Williamson, 2005), a large number of contributions and copyedits to Wikipedia are made only by a small number of individuals who are also very active in the Wikipedia community. While the present results are important to understand the motivations of these core contributors to Wikipedia, further research is desirable to explore potential differences to less frequent contributors.

Moreover, future research might analyze the impact of perceived task characteristics distinctively for the different roles and functions of the participants in the Wikipedia project (such as authors, administrators, software developers). Such work might provide more detailed insight in these different activities, together with more specific measures such as objective data from log files, or results obtained using diaries or Experience Sampling Methods. This would allow to tap into motivational processes more directly and more strictly establish causality between motivational processes and engagement.

The results reported are interesting both for Wikipedia as well as other collaboration projects concerned with sharing information and collaborative writing. The Wikipedia project might benefit from a thorough understanding of the motivation of their participants in order to attract and retain their volunteer contributors even better. Reducing the costs associated with high engagement might facilitate long-term engagement of qualified and experienced contributors. Similarly, improvements to the experience of editing and correcting articles, for example by increasing experienced autonomy and task significance, might attract more of the millions of visitors to become volunteer contributors.

Moreover, our results might also be fruitful for knowledge management systems in business organizations. For instance, the extend and quality of employees' contributions to knowledge management systems in business organizations depend heavily on their individual initiative and motivation. Although the incentive structure clearly differs between business organizations and voluntary work in Open Content communities, there still might be some lessons to be learned from each other. Based on the results reported in this study, business companies who are interested in increasing the individual contribution rates to knowledge management systems might emphasize the significance of these activities for others, for instance by better communicating the consequence of good (and bad) contributions for work processes. Moreover, the strong influence of task characteristics in our study emphasizes factors that increase the intrinsic value of the contributing activities. Apart from autonomy, the technical systems have to be designed accordingly (cf. Arazy, Ji, & Patterson, 2006; Osterloh, Frost & Frey, 2002; Venkatesh, 1999). For instance, the use of wiki software (Majchrzak, Wagner, & Yates, 2006) might provide employees with a more pleasant task experience than more cumbersome software solutions, and increase intrinsic motivation to contribute.

This study provides perhaps the very first empirical view into the motivational processes within the largest Open Content project, trying to explain why so many persons with different educational and occupational backgrounds are working for free in a collaborative writing project, and to extract general insights on motivation in Internet-based cooperation that might be applied to other projects. In doing so, we combined conceptual models from two research

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communities that are usually rather unconnected (i.e., social science and work psychology) in order to strive for a complete picture of the underlying processes. Of course, this initial step has to be replicated, supplemented, and extended by future work.

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Free/Open Source Software and Business: Forming A Migration Policy (Part I)

Kristijan Spirov

Abstract

This paper explores the non-technical issues that arise with migration to Free/Libre and Open Source Software (FLOSS) in Large Scaled Enterprises (LSEs), with special emphasis on human and social issues. The result of the study is a conceptual framework for effective addressing of non-technical issues in a migration policy. The study is of exploratory nature and uses secondary research findings from multiple disciplines: free and open source software, management of human resources, power and conflict, system migration, information systems development, motivation, change management, organizational psychology and social informatics; including anecdotal evidence from FLOSS migrations in practice. A holistic approach has been used during the analysis of the migration issues, based on the key principles of social informatics that IT technology and social contexts are interdependent. The relationship between FLOSS migrations and different organizational contexts is elaborated and it has been found out how lack of vendor support for FLOSS motivates LSEs to improve their self-support of own IT infrastructures. In-depth analysis is performed of the individual and social impact that FLOSS migrations have on enterprise IT personnel, as well as how different individual factors such as age, gender, personal motivations and beliefs may impact on individual migration efforts. The social differences between typical enterprise IT personnel and the FLOSS community are elaborated, as well as how to overcome the communication gap between them. The role of end users in FLOSS migration and relevant issues are discussed. It is proved why staged migration is the most viable option and it is shown how it is related to human and social factors. At the end, a conceptual framework for description of non-technical FLOSS migration issues is discussed, which can be used as a helpful tool in a migration policy.

Chapter 1. Introduction

1.1. Free/Libre and Open Source Software (FLOSS)

This is a brief introduction to the concept of free and open source software, its historical perspective and the international organizations which support it.

Sharing source code between software developers is not a new concept and it exists since the invention of software and programming languages. When computers were still a new technology and were used merely as research tools, people and organizations started to share software source code for practical reasons (Brunelle and Bruce, 2002). Ever since that period the practical side of this phenomenon has been the exchange of different views and ideas for the purpose of more efficient problem solving, while its underlying generator have been the

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social factors which have sustained the gradual progress towards community formation (Figure 1). As Stallman (1999) explains, the software-sharing community existed for many years. But, the development of the software industry, thus commercialization of software, has contributed the social aspect of software development to become tightly controlled within closer boundaries, on institutional level.

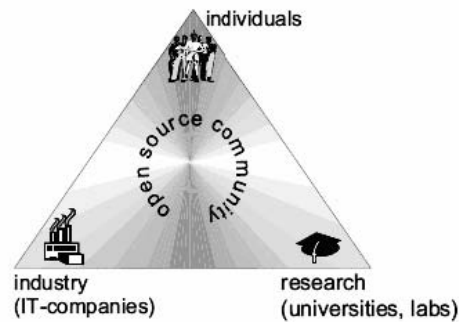


Figure 1: The FLOSS community triangle

When computers reached the business world (Perens, 1999; Weerawarana and Weeratunge, 2003), the rights to software became restricted and fees were charged for each copy. In order to protect their investment and income, enterprises have been forbidding sharing of source code with the outside world. As a reaction, this has triggered the appearance of a large community of developers that support the concept of free exchange of ideas for software development and source code, like in the old times when computers were used as research tools and software was freely shared (Perens, 1999).

There are two major movements within the software-sharing community: one supports the “free software” and the other one supports the “open source software” concept. The first is represented by the Free Software Foundation (<http://www.fsf.org>), an organization which defends the principle that users should be given a complete freedom and rights to exchange or adapt any software code, without imposing any restrictions on these rights. The supporters of “free software” insist that all software code should be freely available and users should be given full rights to use, adapt, change and distribute it. The movement represented by the Open Source Initiative Organization (<http://www.osi.org>) supports the “open source software” concept. This concept is more flexible from a business point of view than “free software” because it allows different models of using freely open source code which may include some conceptual restrictions for users. For example, open source software can be used in combination with commercial software. Although the supporters of “open source” strongly support the above stated freedoms, they do not insist that all software code should be freely open for the users, thus express higher consideration for the investments made by the software creators. Elliott and Scacchi (2003a) show how FLOSS developers actually split into these two subcultures.

Several abbreviations have been used to describe free and open source software concepts. The European community has widely accepted the term FLOSS, where “L” stands for “Libre” and symbolically denotes the freedom. Even though the concepts of “free” and “open-source” software obviously have intrinsic differences, hereinafter they will be discussed as a single concept under the term FLOSS, because they basically share the same ideas that it should be allowed to freely exchange source code. In contrast, the term “commercial software” will be referred to further in the text as COTS (abbreviation of Commercial Off-The-Shelf).

In the above text it was presented that the FLOSS community has a long history and has eventually split into two major movements: free and open source. Within this study they are referred to as FLOSS, abbreviation that is commonly used in EU. The difference between the two movements is not relevant to this study.

1.2. Factors of FLOSS adoption among enterprises

A brief discussion follows about the factors that influence the adoption of FLOSS among business enterprises.

At present, FLOSS is an emerging software concept driven by the rapid progress of information technology, especially by the development of open standards and Internet as a global distribution and marketing channel. By enriching the software market with new products, FLOSS contributes to the commoditization of software (Koch, 2003), a process which inherently pulls down the market prices in the software industry. Lower cost of software is also one side effect of the unique licensing rights given to the users of FLOSS to freely use, copy, adapt and distribute changes of the software without any restrictions. The growing popularity of FLOSS brings many challenges to free enterprises.

Cost is considered (Dedrick and West, 2004; Dedrick et al, cited in Holck et al, 2004; Wheeler, 2002; QNB Intelligence, 2004; The Dravis Group, 2003) as one of the most important drivers for FLOSS adoption among enterprises. However, Ghosh (2003) and Meehan (2005) found out that enterprises consider other reasons for migration to FLOSS as even more important than cost, like stability and security. These attributes of FLOSS are another side effect from the freedom given to software users, because the public availability of the source code for review provides high probability of maintaining high quality of code in general. That is perceived as a huge incentive for migration to FLOSS by enterprises. IT market research (Evans Data, cited in Kuchinskis, 2005) also confirms the finding that lower cost is an important, but not a deciding factor for adoption of FLOSS among enterprises.

The previous findings actually describe a push-pull system established between the FLOSS concept on one side and what enterprises need on the other. This mechanism strengthens the foundation for higher adoption of FLOSS inside the business world, which in feedback generates new development initiatives and further emergence of the concept. It may also be one of the key reasons why more and more IT vendors enrol in these kinds of projects. In other

words, FLOSS is becoming a well-grounded choice for enterprise software users and that also drives more vendors to support it.

On the other side, there are various barriers for migration (Dedrick et al, cited in Holck et al, 2004) like: lack of compatibility with existing technologies, skills and organizational resources, low availability of external technological resources, as well as potential legal barriers. The existence (Barton and Nissanka, 2001) of many types of open source licenses and complicated requirements related to them exposes the potential of FLOSS to cause difficulties. In contrast to this, through a comparative study of EULA (used by Microsoft and other vendors) and GPL (used for most FLOSS) licensing models, Zymaris (2003) points out that even in case of commercial software the user is not legally protected, which is opposite of what many commercial software vendors claim. The Swedish Agency for Public Management Publication Service (2003) also emphasizes that most user licenses for proprietary software products exclude responsibility for flaws.

To summarize, the adoption of FLOSS is emerging among enterprises, and according to some cost may not be the primary factor for this. Still, there are many different barriers for the adoption process, such as technological, human, legal, etc., that enterprises have to overcome.

1.2. Large Scaled Enterprises (LSEs)

The scope of this study are large enterprises that migrate to FLOSS systems. In this section it is discussed why large enterprises are important for the IT industry and how the size of the enterprise may affect the decision for FLOSS migration.

Large scaled enterprises are very important to the IT industry, because they are a segment that invests a lot in technology. The level of adoption of forthcoming IT trends among large enterprises usually gives course to the overall IT industry. According to Gartner (2003), the strength of this sector is crucial for sustaining growth in demand for IT products and services. Spanos et al (2001) point out that enterprise size is an important factor in the adoption of information technology, because large firms are able to allocate considerable resources on new technologies. In that sense, it is important to understand how large enterprises deal with FLOSS, because it is an emerging concept which gradually changes the shape of the IT market, by introducing a different viewpoint on how software should be developed. Adoption of FLOSS among large enterprises has always had strong influence on the public opinion and the predictions for the future of FLOSS. (Figure 2)

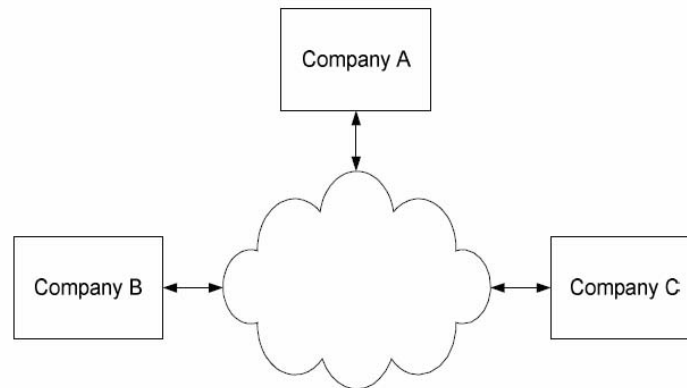


Figure 2: OSS project community

Large enterprises are traditionally organized with a strong vertical hierarchy (Sharma et al, 2002; Dinkelacker and Garg, 2001; Galup et al, 1998). The size and complexity of a large enterprise simply dictates the need for granulation of the organizational scheme. The bigger the enterprise is, the more obvious is the difficulty to flatten the organizational layers. Large enterprises usually have many departments, each managed by a single manager who either reports directly to the CEO, or maybe, in case of a very big enterprise, to a senior middle manager that is responsible for several departments. Large Scaled Enterprises (LSEs) typically have their own internal IT personnel that provide the following functions: in-house software development, system administration and support. In contrast to this, Small and Medium Enterprises (SMEs) hardly have IT teams with all previously defined functions, due to their size.

The role of the IT department in this traditional setting of a LSE is to support the business activities of the enterprise and the employees from the other departments are end users for the IT department. In most large enterprises whose primary business is not IT related, the IT department is expected to support the business and follow an already established company strategy, instead of being a crucial player in creating one. In some top positioned enterprises, IT may have stronger role in the development of a business strategy for reaching competitive advantage, but usually most IT departments have been facing problems of alignment with the business and predominantly cope with every-day operational issues.

When a large enterprise decides to migrate to FLOSS, it should expect a number of complex issues. Most of them a large enterprise will face primarily due to its size. These issues can be of technological or non-technological nature (organizational, human, social) and can influence on the planned process of change. But migration to FLOSS may be different from other migrations, especially because of the capability of introducing new paradigms in the enterprise. There is an apparent need for an enterprise migration policy for FLOSS, in order to guide transition, but also mitigate potential risks. A migration policy should cover not only technical

aspects of the migration, but also organizational, human and social aspects in order to prevent from project failures and potential future disappointments from FLOSS within the enterprise.

To summarize this section, it was explained why large enterprises are important for the IT industry, that they typically have complicated organizational structures and use internal IT personnel to support deployment of information technology. It was discussed that there might be specific migration issues due to enterprise size, but also that FLOSS might create new paradigms.

1.3. FLOSS in European LSEs

This section briefly presents how LSEs are defined in Europe and some statistical data in order to provide a clear picture about the actual size of the LSE sector. The current state of FLOSS adoption in Europe is also presented.

LSEs are defined by the European Commission (recommendation 96/280/EC) as independent enterprises that have more than 250 employees and annual turnover over 40 million. According to the European Observatory for SMEs (2000), there are around 40,000 LSEs in Europe, which represents only 0.2% of the total number of European enterprises. Only around 2,000 of these enterprises are located in the non-EU countries, a fact which is closely related to the economic differences between EU and the rest of the countries. Furthermore, an average LSE in the EU has 1010 employees, while in the non-EU countries their average size is around 780 employees. The average size of the IT team in LSEs is around 10-40 people. Empirical studies of large enterprises show (e-Business Watch, 2002b) that the size of IT departments may dramatically vary between business sectors.

There is extensive experience in the use of FLOSS in the public sector in Europe (The Swedish Agency for Public Management Publication Service, 2003). This means that there is support from national governments. This motivates the adoption of FLOSS among enterprises. FLOSS has long tradition in Europe. For example, Dempsey et al (2002) conclude that the Linux project has deep European roots. According to the research of International Institute of Infonomics (2002), the numbers of companies that use FLOSS are not the same in different EU regions and that provides some information about the actual popularity of FLOSS within these establishments, but also about the maturity of the software markets.

In some EU countries (International Institute of Infonomics, 2002; QNB Intelligence, 2004), like Germany for example, the adoption rate of FLOSS in LSEs is very high (around half of all large enterprises have performed formal evaluation of some FLOSS products), while in others, it is substantially lower. This may be a result of cultural differences. The adoption of FLOSS in LSEs in the non-EU regions is lower than in the EU. Cosovanu (2003) explores the reasons behind this issue in the peculiarities of the local software markets in Eastern Europe, which still experience a lot of fear and inertia within the enterprises.

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To recapitulate the above, the number of LSEs is very low compared to the total number of enterprises and there is a big difference between the size of the LSE sector in the EU and non-EU countries. Regarding FLOSS, it has higher level of adoption among EU countries. This may be partially due to the strong support for FLOSS from national governments in EU.

1.4. Aims and objectives

The aims of this study are to identify and elaborate the non technical issues that are experienced by large commercial enterprises (LSEs) when they carry out partial or full migrations to FLOSS, as well as to discuss the implications derived from them. The primary focus of the study is on identification of human and social issues with such migrations, through appropriate reflection on the organizational contexts of large enterprises in general.

In pursuit of the aims of this study, the following objectives are set: to identify the FLOSS migration issues that are specifically related to IT personnel in large enterprises and also those that are common for end users. Other objectives are to explore the dependency between various human and social issues and the level of FLOSS migration (partial or full), as well as to explore and discuss the advantages of a staged migration in favour of a full roll-out to FLOSS systems.

1.5. Research questions

The main focus of the study are the following research questions that address human and social issues with FLOSS migrations in LSEs:

- What are the human and social issues with migration to FLOSS in LSEs?
- Are these issues different from those in other types of migration projects?
- Do these issues vary across different types of organizations?
- What best practices can be defined for dealing with human and social issues with migration to FLOSS in LSEs?
- Can FLOSS change the corporate culture in LSEs?

The main benefit of this study, through detailed discussion and analysis in relation to the above research questions, is expected to be a better understanding of the human and social issues that are common during migrations to FLOSS in LSEs, with purpose of developing an outline of a conceptual framework for dealing with those issues as a tool for addressing them effectively in a corporate FLOSS migration policy.

1.6. Structure of the dissertation

The content of this paper is organized with the following structure: Chapter 1 is an introductory chapter to the topic. Basic terms are defined and brief history of FLOSS is presented in section 1.1, while the adoption of FLOSS among the business is described in 1.2 In 1.3 the main aspects of large enterprises are introduced and the situation with large enterprises in Europe is briefly discussed later in 1.4 The aims and objectives of the study are revealed in sections 1.5

and 1.6 respectively. Chapter 2 presents an insight into how organizational context of LSE relates to FLOSS migration. In 2.1 it is discussed why the context is important for the analysis, in 2.2 it is discussed what distinguishes FLOSS migration from other kinds of migrations, in 2.3 it is explained why the community perspective is important for LSEs, while in 2.4 the importance of non-technical issues with FLOSS migrations is stressed. Chapter 3 presents the research methodology which is used for finding the relevant answers to the research questions. Section 3.1 reveals the gap in existing academic knowledge which also defined the problem domain of the study, while 3.2 presents and justifies the chosen research methodology. Chapter 4 deals with the critical evaluation of non-technical FLOSS migration issues. The analysis performed in this chapter is divided into three main parts. In section 4.1 the human and social issues faced by the IT department with FLOSS migration are discussed. Both individual and social aspects are analyzed in this section. The role of the end users in FLOSS migration and the issues related to them are discussed in section 4.2 Separate analysis of the human and social issues that urge the need for staged migration, is performed in section 4.3 After the in-depth analysis of the human and social issues, finally in Chapter 5 in section 5.1, the conclusions of this paper are presented and answers provided to the research questions of the study, while in 5.2 recommendations are given for future research.

Chapter 2. An insight into migration to FLOSS in organizational context of LSEs

This chapter provides an insight into FLOSS migrations within a broader organizational context of LSE. In the first section it is discussed how the organizational context of LSE is related to the different issues with migration projects, how organizations from inside perceive the role of internal IT personnel and what are the typical problems with human resources with these kinds of projects in LSEs. In the next section it is elaborated what makes FLOSS migration similar or different from other kinds of system migrations, regarding the human and social issues. It is discussed about various approaches of LSEs towards the perspective of belonging to a wider community and why this community perspective is important for FLOSS migrations. In the last section a discussion is made about the importance of addressing human and social issues with FLOSS migrations in LSEs.

2.1. Importance of organizational contexts in which migrations take place

In the text that follows it is discussed how the organizational context of LSE is related to the issues with migration projects. It is presented how IT is perceived internally in LSEs and what kinds of problems with human resources are typical for these kinds of projects.

When a large-scale IT project like FLOSS migration is undertaken in a large enterprise, it usually affects many segments of the enterprise, especially the core departments which are perceived from inside as the main generators of profit. The active involvement of end users in IT projects, especially from core departments, is very important for avoiding potential failures and disappointments. But for end users in LSEs, IT is just a service which provides the tools to do the job or improve efficiency. The major expectation (Hirschheim and Lacity, 2000; Sumner and Klepper, 1987) that users have for IT performance is high service quality and this imposes

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external pressure to the IT personnel. In organizations where IT is involved in making company-wide strategic decisions, this pressure is even higher.

Employees of a large organization share the organizational culture in the environment they work in, but also have personal motives. Differences between motives may induce conflicts between IT and non-IT personnel inside the organization during the FLOSS migration project, because non-IT personnel could treat the migration as a trouble that nobody needs at all. The experience of managers in LSEs (Dedrick and West, 2003; McHugh and Donnelly, 2004; Parker, 2000) is that users do not have the knowledge and do not care. Non-savvy users (Vaden, 2003) may need an extra effort to justify the migration. Things can become more complicated if the relationship between the IT department and the business units has been prone to conflicts, especially if such conflicts have longer history, spanning over more than one generation of managers.

If a decision for migration to FLOSS is put in a general context of a large enterprise, the whole migration effort may seem to be devalued compared to the high business strategic enterprise goals and objectives. As it was previously described, the decision to migrate to FLOSS will typically not have the same meaning for end users and IT personnel. While for IT personnel the migration may mean professional challenge or chance for improvement of professional careers, for end users it may mean unnecessary trouble. Or even worse may happen, the management to see it as an opportunity, while to be perceived as a cumbersome, not needed change by the IT personnel. But regardless of the specifics of the particular setting, it is very important that if a LSE decides to migrate its information system on FLOSS platform, ultimately this will be done only with a management decision.

FLOSS can not be adopted at any significant scale (Holck et al, 2004; Larsen et al, 2000) if it conceptually does not fit into the IT strategic framework that has been set up by the top management, except maybe in certain areas with low visibility, like server platforms. All individual initiatives, even those engaged in shadow, regardless of the level of influence, cannot force major change of this kind because of lack of authority. Major change is possible only if the management decides to make it. Furthermore, the motives for FLOSS migration of management and IT personnel could be very different, especially if the migration initiative did not originate from IT personnel. And some individuals may favour FLOSS simply because of their own beliefs that software should be free. These differences should be treated as risk factors during migration projects. In fact, any serious dissents among the IT personnel could potentially cause disruption of migration projects, or even failure.

From a technical perspective, migration is the actual conversion of a computer system from one state to another. From a holistic perspective, migration is represented with a set of procedures and steps that are aimed to navigate the safe change of all constituting parts of the information system of the enterprise from the commencing state to the desired one, i.e. not only computer systems, but also human resources and organizational frameworks. The migration should be well defined with a migration policy that should cover not only technical issues, anticipate potential problems and offer practical solutions for resolution of such problems.

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To summarize the above, there are differences between how IT personnel and end users view IT projects, since their motives are distinct. Since migrations have power to change people and organization as well, it is very important to understand the organizational contexts in which projects are performed and to properly address the human and social issues in a migration policy.

2.2. Attributes of FLOSS migrations

The following question can be framed regarding FLOSS migration: what is similar and what is different between FLOSS migration and other kinds of system migrations, concerning the associated human and social factors? This is discussed in the paragraphs that follow.

As with other types of migrations, migration to FLOSS is not an easy process and there are many hidden obstacles and risks on the way. Internal users may face many difficulties with migration. Kleintop et al (1994) point out that users will better accept a technology if there is: full support from top management for the usage of technology; training; open communication with employees and their involvement in the decision making process. Yet participation alone (Butler and Fitzgerald, 1997) does not guarantee that the information system will be efficiently operated and used, because there is a tendency in organizations to view the development process as a mechanism for resolution of internal power battles. Therefore it is very important to provide a trustful organizational framework.

The inter-group conflict (Wynekoop and Walz, 1999) which is proportional to the knowledge and expectation gaps between internal groups may be suppressed through improvement of communication. Though it has to be considered that (Nilsen and Sein, 2004) neither knowledge nor communication helps when the support function is not properly organised and more importantly, when users are not informed about how it is organised. If the organization (Holck et al, 2004) has little competence in FLOSS, the migration will be perceived as a high risk operation with little or no support from the IT department. This could produce conflicting situations between IT and their business counterparts, or activate dangerous residues if such conflict existed in the past.

One of the difficult problems that an IT manager may face in a LSE that decides to migrate to FLOSS, is that not everybody would necessarily agree with the FLOSS concept at the first place. Even though programming is (Nuvolari, 2003) a creative problem-solving activity, there are cultural differences between IT professionals in how computer playfulness and personal innovativeness are expressed (Fardal and Tollefsen, 2004). Therefore, while other types of software migration would be expected to cause shallower distress to an IT professional of more temporary character, inflicting migration to FLOSS is about introducing and accepting a whole new framework of ideas and attitudes, i.e. creating (Dubie, 2005) a cultural difference. The concept of availability of source code and the rights to freely modify and adapt it, as well as freely copy and distribute the software, are rights which the users of COTS are not familiar with. FLOSS promotes the culture of knowledge sharing and level of collaboration that IT personnel may not be used to.

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The individual attitudes towards FLOSS inside a large enterprise will most likely resemble patterns that surround this concept. Some IT workers will like it, some will oppose it, while others will be ignorant. As in the online communities, it is very likely that the enterprise will have its own zealots and heretics regarding this topic. Like in the flame wars inside the online community, similar disagreements may occur between the participants of the migration project. Some people may even dislike the concept so much that they would be ready to leave their jobs hoping to save their own careers. Staged migration to FLOSS could support solving these kinds of problems since it would provide time for people to accommodate to change.

The important question is if the intrinsic values of FLOSS can be used to overcome at least some of the above mentioned problems, in the pre-migration period. Gallivan (2000) found out that the perspective of community of practice is considerably stronger than applying of traditional organizational models among knowledge workers. Replicating (Melian et al, 2002) collaboration styles of open source in an enterprise positively influences on creating diverse networked groups within the enterprise. Strong organizational cultural beliefs (Elliott and Scacchi, 2003a) tie networked groups together so that conflict is more easily mitigated and resolved. The sharing culture behind FLOSS is obviously very compatible with these propositions for better internal functioning of organizations. The community perspective is thus very important to be understood, because it can be sponsored during FLOSS migration projects for improvement of internal collaboration and communication.

To conclude the previous discussion, like any other IT project, FLOSS migration may be perceived differently within the organization, therefore a full support from top management is needed. It also requires strong commitment from the IT personnel. FLOSS promotes the culture of knowledge sharing and collaboration and this is the outstanding attribute of FLOSS migrations. Everyone should be carefully guided towards adoption of these values for a successful migration.

2.3. The community perspective

In the following paragraphs the different approaches of enterprises towards the community perspective are discussed and it is explained why the community perspective is important for FLOSS migrations.

When enterprises migrate to FLOSS platforms, their contribution to the community is not uniform. The majority of enterprises are passive users of FLOSS and communicate with the community primarily when they need support, but they don't share source code. Rossi (2004) claims that not all enterprises contribute back to the community. Some enterprises decide to release some of their in-house source code in order to reduce the cost of its development and maintenance (Hawkins, 2004; Bac et al, 2005). Still, many organisations (Fitzgerald and Kenny, 2003) are not comfortable with making changes to the source code of the FLOSS products they use. Other enterprises frame software development in their own organizational boundaries in order to enforce their intellectual property (Kogut and Metiu, 2001).

These differences reflect how different enterprises react on various IT challenges. Egri (2001) believes that companies are reacting on IT challenges in different ways. The level of IT demand has significant impact on this. Kwan and West (2004) point out that there is considerable variation of IT demand within organizations and even organizational subunits. Enterprises will more likely be open to new technologies (Dedrick and West, 2004) when IT is strategic to the business.

Ciborra and Andreu (2001) point out that strategic use of knowledge and its management depends on particular organizational settings. Therefore it is explainable why there is no single pattern in how LSEs collaborate with the FLOSS community. However, the results of the survey conducted by CIO Insight (Agostino, 2005) shows that adoption of FLOSS has fostered innovation in almost two thirds of the enterprises. Adopting FLOSS concepts may advance the attitude towards creativeness and innovation within enterprises and the relationship with the FLOSS community is an important catalyst in this process.

One possible effort to become closer to the FLOSS community is to embrace its development model in the enterprise, thus provide similar conceptual environment. Researches claim that deploying an open source model internally can improve work effectiveness and collaboration (Melian et al, 2002; VaSoftware, 2004; Scacchi, 2002a). But this model may not work for all enterprises (Sharma et al, 2002; Ven and Verelst, 2004) and management appears to be the greatest barrier (VaSoftware, 2004). IT managers have probably the most important role in the decisions that shape enterprise involvement in the works of the community. Bonaccorsi and Rossi (2004b) suggest that the level of contribution to FLOSS projects much depends on the social and technological motivations within enterprises. They also found out that in general enterprises join FLOSS projects less then individuals. One possible explanation is that the motivational frameworks which reflect the settings in majority of enterprises are still adjusting to the global community.

Enterprises with a weak commitment are not likely to adopt community-oriented behaviours (Bonaccorsi and Rossi, 2005). Existing research shows that (Wagner, 2005) enterprises which are accustomed to collaborative work with other organizations seem to gain more from FLOSS than those with an internal focus who value technology through cost savings. Lagace (2003) points out that successful enterprises actively foster sense of inclusion among their employees. Still majority of enterprises emphasise economic and technological reasons for starting their contribution to FLOSS (Bonaccorsi and Rossi, 2003), which is not common for individual contributors.

In the previous text it was explained that there are different patterns in how LSEs collaborate with the FLOSS community. The relationship with the FLOSS community eases the adoption of FLOSS, a process which seems to foster innovation. It was explained that this is the reason why the community perspective is important and that strong commitment from the whole organization is needed for adopting behaviours that are community oriented.

2.4. Importance of addressing non-technical issues

A brief discussion follows regarding the importance of addressing non-technical issues with FLOSS migrations.

Human resources supported and guided by an appropriate organizational framework actually operate, use and change computer systems and a system can be replaced with a new one only if the personnel are well prepared to perform and adopt the change. While the number of failed IT transformation initiatives in enterprises is very high (Sirkin et al, 2005), researchers point out that the main reasons behind these failures are attributed to non-technological issues, (Dravis, 2003; Nelson and Joshi, 1993; Batler Group, 2005) like organizational and social. LSEs have to learn from these negative experiences when they plan to migrate to FLOSS. Otherwise, space may be left for unreasonable interpretations of migration failures on expense of technology. Research indicates (Sauer et al, 1997; Batler Group, 2005) that IT managers in enterprises are not able to manage satisfactory many of the most common causes of failure.

It is very important to address these findings in FLOSS migration projects by implementing them in a migration policy. If the IT management is not competent and skilled to control the project objectives in FLOSS migration projects where there are many non-technological factors that may affect the project outcome, then it is impossible to expect clear direction for the action of the IT personnel and much of the project phases may be left to spontaneous flow. This is very dangerous for the integrity of all enterprise resources involved during and after the migration. Scacchi (2004a) points out that enterprises risk problems if people issues are slighted or ignored in any of the project phases. In these cases the success could be compromised even if the technical side of the proposed change was flawless.

To summarize what was presented above, addressing non-technical issues with FLOSS migrations through building migration policies may reduce the number of failed migration projects.

2.5. Summary

In this chapter it was presented that IT personnel and end users view IT projects differently due to different motives. It was argued that it is important to understand the organizational contexts in which FLOSS migration projects are performed and to address the human and social issues in a migration policy, because beside technology, migrations as well change people and organization. In the second section it was explained that the perception of FLOSS migration may vary internally in LSEs, due to which full support from management is needed and strong commitment from the IT personnel. A prerequisite for a successful migration is the guidance of employees to adopt the culture of knowledge sharing and collaboration which is promoted by FLOSS. In the third section the different patterns of collaboration between LSEs and the FLOSS community was explained. The fact that relationship with the community eases adoption of FLOSS and triggers innovation, led to conclusion that the community perspective is very important and that adopting the principles of the community requires strong

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commitment, especially from IT managers. At the end it was discussed that addressing human and social issues FLOSS migration policies may reduce the number of unsuccessful migrations.

Chapter 3. Methodological issues regarding the study

As elaborated in the introductory chapter, the purpose of this study is to identify and discuss the non technical issues with FLOSS migrations in LSEs. The study focuses primarily on human and social issues with FLOSS migrations, through appropriate reflection on the general attributes that characterize the organizational contexts of LSEs. The analysis of these issues requires familiarity with a range of research disciplines, because human and social aspects in the area of information systems research are inherently considered as very complex. In this chapter the methodological issues regarding the research area of the study are discussed. In the first section the gap in the existing academic research regarding FLOSS migrations will be presented, while the section that follows the methodology used in this study will be elaborated, which is exploratory research with analysis of literature from multiple disciplines and secondary data. Justification is offered for the chosen approach.

3.1. Issues related to research of FLOSS migrations

The discussion in this section is about the gap in existing academic research that may be identified as lack of knowledge regarding non-technical issues with FLOSS migrations and FLOSS adoption in LSEs in general.

The main gap in the existing academic research related to FLOSS migrations is that existing literature covers predominantly technical aspects of migration to FLOSS. IDA Open Source Migration Guidelines (European Communities, 2003) for example, one of the most detailed FLOSS migration guidelines, only modestly highlights the human issues that have to be considered and is focused predominantly on the technical aspects of FLOSS migrations. The same shortcoming is found out in other well known migration guidelines (KBSt, 2003; Treasury Board of Canada Secretariat, 2005; Almond et al, 2004). All of the existing guidelines concentrate mainly on the technical side of FLOSS migrations. Nevertheless, the number of published guidelines for migration to FLOSS is growing. At the time of preparation of this paper, no previous research could be found that would offer systematic and structured analysis of the complex social phenomena present with FLOSS migrations.

Restrictive access to research data may be one serious constraint that gives some explanation to why non-technical issues have not been systematically treated by researchers. Seidel and Niedermeier (2003) claim that most of the enterprises who are involved in FLOSS activities do not disclose information about the transformation of their internal processes and culture towards FLOSS. Spiller and Wichmann (2002) point out that measuring the professional use of FLOSS in organizations is more difficult than measuring the use of COTS. Another issue is the domain size, i.e. the number of LSEs is very low indeed, which makes it even more difficult to understand the non-technical issues that are experienced during migration projects and to draw general conclusions about them.

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Although the research area (Holck et al, 2004) of FLOSS is relatively young, there is a growing number of research contributions that are investigating the phenomena related to FLOSS from different perspectives. However much less attention has been devoted (Dedrick and West, 2004; Ghosh et al, 2002; International Institute of Infonomics, 2002) to FLOSS activity of enterprises than to FLOSS activity of individuals. FLOSS adoption in the enterprise domain and its social and organisational impact has not received so much attention from researchers (Conlon and Carew, 2005). Gasser and Scacchi (2003) state that one of the topics needing further research is identifying what policies should guide the acquisition, adoption, or use of FLOSS in enterprises. Dedrick and West (2003) point out that comparatively little research has been done to determine how the organizational adoption of FLOSS is different from adoption of other technologies. It is very important to expand the academic knowledge in this area, not only for filling the obvious theoretical gap, but also because of the practical implications it could have on enterprises who undertake FLOSS migration projects.

The fact that FLOSS is still an emerging area explains the lack of academic knowledge about the behaviour of LSEs regarding this topic. Nikula and Jantunen (2005) point out that FLOSS adoption is still in early phases. Therefore there is lack of availability of clear directions and procedures. Furthermore according to Briggs and Peck (2003) many migrations are performed without a recognizable migration methodology. It is a real challenge for an IT manager to incorporate human and social issues in a clear and phased FLOSS migration strategy that would form basis for many positive changes in the whole enterprise. This study tries to fill the gap in the existing research area and provide a more comprehensive view of how migration to FLOSS and its collaboration and knowledge sharing principles affect enterprise employees.

To summarize what was discussed in this section, there is a knowledge gap in the area of FLOSS migration in LSEs and the weakness of existing migration guidelines is that they do not offer framework for dealing with non-technical issues. This study tries to fill this gap.

3.2. Description of the research methodology

In this section the research methodology chosen for this study is presented and justified in respect to the previously described knowledge gap in the observed problem domain. It is also explained why and how the research framework of the relatively new research area called social informatics has been deployed as a helpful tool in the analysis.

In order to pursue the goals of this study most effectively while considering the lack of academic knowledge in respect of the area of FLOSS migrations, which was described in the previous section, it is chosen the research in this study to be of exploratory nature. Exploratory studies are used for exploring new areas (Saunders, 2000) from which conceptual frameworks are built and form basis for some future studies (Lynn, 1991; Tellis, 1997). The exploratory study starts with a holistic approach (Routio, 2006) and by saturating data from multiple viewpoints, a deeper understanding of the problem is reached and new theoretical framework finally emerges (Figure 3).

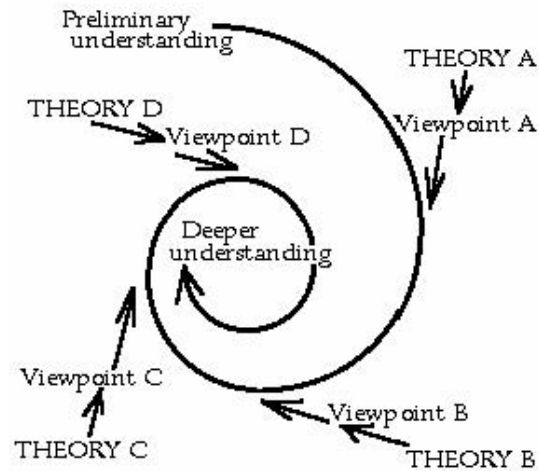


Figure 3: The method of alternating point of view in exploratory research

According to Saunders et al (2000), one of the principal research strategies of conducting exploratory research is through a review of existing literature. For the purpose of gathering research information for this study, an extended literature review was conducted and diverse qualitative secondary data was collected from prior research findings from the following research disciplines: free and open source software, management of human resources, power and conflict, system migration, information systems development, motivation, change management, organizational psychology and social informatics. The multidisciplinary approach was necessary for effective analysis of the human and social phenomena that exist with FLOSS migrations in LSEs. Changes of information systems affect also non-technical settings, thus these implications do not fit completely into any particular and distinct research discipline and instead they have to be analyzed in parallel from different research angles.

The discussions throughout this study moderately reflect the personal experience of its author as a systems manager in a large Eastern European enterprise in the area of financing, which heavily relies on proprietary software products and development platforms and IT personnel which is not much familiar with FLOSS products and the underlying principles of the FLOSS community. The results will be integrated and discussed through a presented outline of a conceptual model for understanding human and social issues with migration to FLOSS. Any effective migration must address these issues (Paul, 2005).

Information systems are constituted of technology, people and organizational settings. One research framework that provides a scheme for examining social and technical processes in networks of people who work together, are socio-technical interaction networks (Scacchi, 2004a). The socio-technical approach is aimed for technology oriented environments. Lyytinen (1987) points out though that socio-technical approaches may suggest too limited change strategy since their image of an information system is limited to a technical system. The dynamics of information systems can not be explained through information technology

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observed separately from social phenomena. Therefore a holistic approach is needed for better understanding of issues related to technological changes in complex environments.

A holistic view of technology, processes and social structures is offered with the framework suggested by a relatively new research field, known as social informatics, which is complementary to the principles of exploratory research explained in Routio (2006). Kling (2000) points out that a key idea of the social informatics research is that the social context of information technology has a significant role in influencing the ways in which people use information and technologies, thus affects the consequences for organizations. Social behaviours can not be treated separately of technologies. The discussion that follows in this study will be guided with the key principles of social informatics. The rationale behind this is, as explained previously in the analysis of FLOSS migrations in organizational contexts of LSEs, the great diversity of behaviours in LSEs that can be found with large IT projects. This proves that social phenomena cannot be isolated from the specifics of the organizational environments and technological settings, instead they emerge from them.

The greatest dangers in exploratory studies are premature releasing of conclusions and overextending the exploratory phase by inadequate level of diversity of viewpoints (Lynn, 1991). These problems have been addressed in the study by strictly focusing on several areas where non-technical issues with FLOSS migration fit into and these are: the impact that FLOSS migration may have distinctively on IT personnel and end users; as well as the impact of staged FLOSS migration on the people involved and on the social setting. At the end it is also worth to note that this work represents only a preliminary exploratory study which offers an elementary outline of a conceptual framework that can be extended in some future research.

In this section it was discussed that the deployed research methodology is exploratory study. Justification of why this methodology had been used was elaborated, as well as how the potential weaknesses had been addressed. It was also explained that principles of social informatics were used in the analysis because of their holistic approach.

3.3. Summary

In this chapter the methodological issues regarding the study were discussed. In the first section a gap in the existing knowledge about the area of FLOSS migrations in LSEs was identified. The weakness of existing migration guidelines were described in sense that they do not deal with non-technical migration issues. It was pointed out that this study tries to fill this gap. In the last section the exploratory research methodology is elaborated and justified. The potential weaknesses of the methodology had been addressed as well. It was also discussed that principles of social informatics were reflected throughout the paper, since social informatics offers a holistic view on various phenomena in information systems.

Chapter 4. Critical evaluation of non-technical FLOSS migration issues

In this chapter a critical evaluation of non-technical FLOSS migration issues is performed. These issues have been divided into three categories, which are the main defined viewpoints on the problem domain. Each of them is presented in a separate section.

The first and largest category of explored issues contains the issues related to IT personnel. It is first presented how lack of external support impacts on internal processes of change. The next topic is the impact of FLOSS on internal culture of LSEs. It is explained why it is important for enterprises to contribute to the community and how this involvement impacts on the internal social behaviour. Later in the text a wider analysis is performed about attitudes and motivation regarding FLOSS and about impact of factors like age and gender on FLOSS migration outcomes. The importance of skills and training is also explored. Ideological issues related to bridging the gap between internal culture of LSEs and FLOSS community follows next. While exploring the importance of online communication, at the end there is a discussion about establishing links with the community and identity issues in that environment.

The second category of explored issues includes the ones related to end users, their profile and role in the FLOSS migration project. Further in the text there is a discussion about importance of training and challenges associates with it. The importance and challenges of participation of end users in FLOSS migration projects is also observed in detail, especially in relation to internal conflicts and power distribution. In the last part it is discussed how to fight resistance to changes induced with FLOSS migrations.

The last presented viewpoint on the problem domain is analysis of the impact of staged migration. It is explored how staged migration affects end users and internal groups and at the end it is explored how desktop migration to FLOSS platforms affects end users.

4.1. Challenges and opportunities for IT departments

4.1.1. The impact of different vendor support for FLOSS and COTS

In the following text it is discussed how external support models for FLOSS differ from support models for COTS. The impact of this issue on enterprises is also analyzed.

IT departments in large enterprises are typically segregated into organizational units that are responsible for in-house software development, system administration and end-user support (helpdesk, technicians, etc). IT departments also communicate with multiple external vendors who provide different support and services. Adopted FLOSS solutions certainly have to be supported during and after migration is performed. The lack of vendor support has been claimed to be one of the most serious barriers for adoption of FLOSS (Gustafson and Koff, 2004; Dedrick and West, 2003; Vile, 2005; Koch, 2003; Meehan, 2005; QNB Intelligence, 2004; Forrester Research, 2003, cited in Williams et al, 2005; The Swedish Agency for Public Management Publication Service, 2003; Scherler, 2004). Wang and Whitehead (2001) explain that it is even more difficult to receive global support for FLOSS, especially in non-English

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speaking areas due to many contributing factors. McHugh and Donnelly (2004) point out that without the support from commercial enterprises, FLOSS would not have sustained growth in popularity.

There are several scenarios to support FLOSS in a large enterprise: to rely on external vendor as a gateway between the organization and the FLOSS community, to rely on internal resources, or to deploy some mixed approach. Gustafson and Koff (2004) point out that the last scenario is a bridge to the open source world because both the vendor and the organization have access to the source code. Holck et al (2004) have done extensive research on these scenarios and found out several ways in which organizations can participate and contribute to FLOSS projects: in-house source code improvements, documentation writing, error reporting, bug finding and fixing, suggesting improvements, supplying and maintaining technical infrastructure, participating in management of the community organization, responding to help requests and supporting local FLOSS communities.

The relationship between customer and vendor in FLOSS is fundamentally different from that in COTS, more obscure and more robust (FFIEC, 2004; Holck et al, 2004), because there is a wider range of choice for FLOSS users. Dedrick and West (2004) claim that vendor support is more important to LSEs because they have the financial means to afford it, while small firms are more likely to rely on their own skills and free support from the FLOSS community. The findings of QNB Intelligence (2004) suggest that promotion of Linux by large mainstream vendors such as IBM and Oracle has increased the formal evaluation of Linux for 75% in large European enterprises. McDaniel (2000) confirms that announcements of FLOSS support by large IT companies have changed the perception of IT managers in large organizations. There are even FLOSS products (Wagner, 2005) for which there is no support available from the community and enterprises should find vendors willing to provide that support.

Williams et al (2005) suggest that the above concerns are becoming weaker partly because companies understand the FLOSS development model better and learn how to support themselves through time. Self support allows greater flexibility for IT personnel (Figure 4). There are also a diverse and growing number of support options (The Dravis Group, 2003) and as demand extends, larger vendors will likely increase their service offerings in FLOSS support. Support for FLOSS projects (David et al, 2003) from external organizations has already increased significantly in the last decade. Therefore, if vendors deliver and support FLOSS solutions (Gustafson and Koff, 2004), from the organization's perspective the support issue can be actually nonexistent.

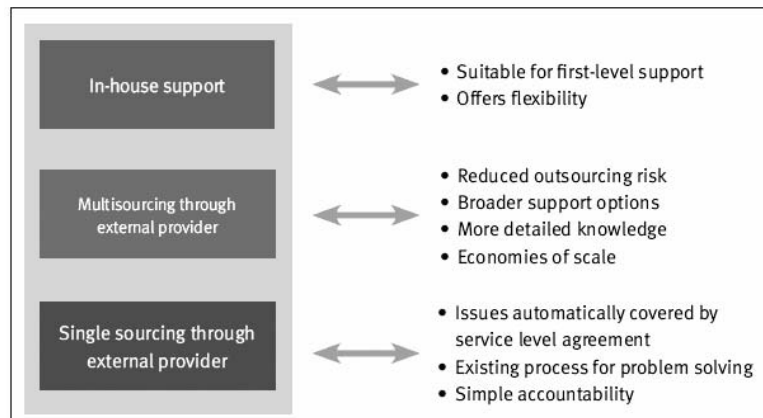


Figure 4: Support options for FLOSS

But problems (Davis et al, 2000) can often be beyond the capacity of the support of the commercial vendor, and the enterprise can resolve them in the same manner as most FLOSS issues, because in general FLOSS authors are more accessible than developers for commercial vendors. Internal support (Lassen and Sorensen, 2001) can also be organized. But this task is not easy. Sirkin et al (2005) explain how organizations often underestimate their ability to build internal support. Organizations are just starting to learn how to overcome this gap. Actually, FLOSS is now transforming the way how software is supported in enterprises (Koch, 2003; Fitzgerald and Kenny, 2003; WatchIT, 2004). Organizations begin to learn how to support themselves by involving in the FLOSS community.

In the previous text it was discussed that support models for FLOSS differ from support models for COTS in sense that they are more obscure and that enterprises begin to learn how to provide self support. The impact of this on enterprises is that they gradually involve in the FLOSS community in different ways.

4.1.2. Impact of FLOSS on the internal culture

The following discussion is about the impact of FLOSS on the internal culture of LSEs. It is discussed how internal groups in LSEs distinguish from the FLOSS community, why it is important for enterprises to contribute to the community and how this involvement impacts on the behaviour of internal groups.

Active involvement helps in fostering a sense of community (Steward et al, 2001), and the community is often first line technical support when problems occur later. Of course, every type of involvement in FLOSS (GITOC, 2003) means different requirements, commitments and benefits, and correlates to some particular implementation approach. Communities exist around common interests (Figure 5). IT personnel and especially IT management, have central role in discovering the real values of FLOSS, not only for the economic benefit of the enterprise, but also for building up new internal social relationships. It is because the impact of FLOSS on the

organizational culture is evidently made by deployment of information technology, a resource which is managed by IT departments. Melian et al (2002), as well as Dinkelacker and Garg (2001), explore how communities of practice within a large enterprise can be encouraged by software technologies, maintaining knowledge networks, adopting third party engagement and promoting contribution.

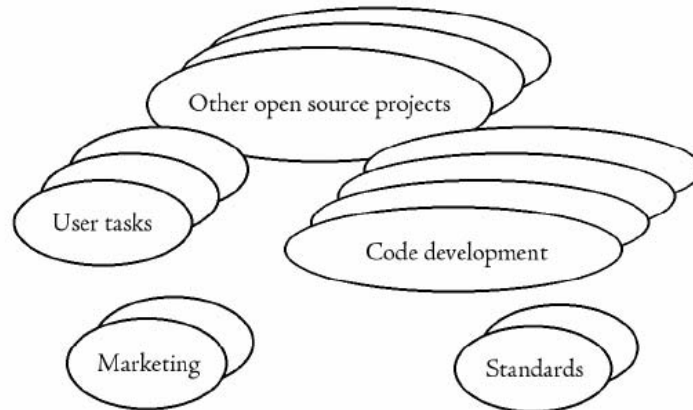


Figure 5: Communities built around common interests

Considering the above, migration to FLOSS does not change only technology in the organization. It also creates conditions for establishing a dynamic connection between the internal organizational culture and the FLOSS community. The above analysis shows that with migration to FLOSS enterprises must prepare their internal forces to first become acquainted with community standards, in order to be able to further strengthen this relationship and provide efficient support. Relying exclusively on external vendors is not enough, because organization would not reap the real advantages of FLOSS. Companies may encourage developers to participate in FLOSS projects as this (Hars and Ou, 2002) can expand their skill base, promote peer recognition as external factor to individual motivation and the same may be applied for users as well. This task is far from easy.

Like large social groups (Elliott and Scacchi, 2003b) with beliefs and values manifested in norms that form behavioural patterns, enterprises have their own unique cultures that form guidelines for employees how to do things internally, deal with uncertainties and establish some degree of order in the organization's social life. These internal expectations can be very different from the ones shared within FLOSS communities. The FLOSS community is differentiated by a distinct ideology that consists of mutually related norms, beliefs, and values (Stewart and Gosain, 2001; Stewart and Gosain, 2003; Elliott and Scacchi, 2003b; Scacchi, 2004a). Dahlander (2004) points out that enterprises involved in FLOSS projects have to balance the possibility of appropriating returns, while maintaining good relationship with the community and compliance with its norms and values. Otherwise, if interests collide then conflicts may arise. As Domino et al (2003) define, conflict begins when personal goals,

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attitudes, values or beliefs are not accordant with those of another individual. The same applies to social groups.

Over time, subcultures within an organization, such as occupational subcultures (Elliott and Scacchi, 2003a) may manifest their own beliefs and practices that make them distinguished from other groups (Guzman et al, 2004). But as teams develop through time (Trimmer et al, 2000) so do their norms. Gallivan (2000) found out that formation of attitudes, values, and norms is strongly influenced by opinions within social and professional circles. The development of the internal teams in a LSE and their mutual collaboration in different projects can actually reshape the internal subcultures in the enterprise. This is a spontaneous process, but also represents a deep reflection of management decisions, quality of human resources, cultural determinants, etc. Therefore it is important how FLOSS migration impacts on whole teams.

The main question is how enterprises can intentionally and systematically streamline this development in the direction to make their own subcultures ideologically closer to the FLOSS community. Thus provide the foundation for efficient internal support. Training about the founding principles of the FLOSS community would seem to be one of the first logical steps forward. However, Gallivan (2000) identifies the problem that trainers and researchers mostly conceptualize IT training at the individual level, rather than the sharing of attitudes, values, and norms relevant to groups. Furthermore, he claims that assimilation of such values, norms, and beliefs occurs more effectively directly on the job. Considering the above, special emphasis has to be put on group preparation for FLOSS migration.

It was discussed that internal groups in LSEs distinguish from the FLOSS community and it is important for enterprises to contribute to the FLOSS community in order to maintain proper support for FLOSS migration. Training is thus important, especially for whole teams, for adoption of FLOSS concepts.

4.1.3. Coping with differences between IT personnel

IT personnel may react differently on FLOSS migration efforts. Particular incentives may help in resolving problems, but may not be suitable for every job position. The analysis below distinguishes the attitudes of developers and administrators towards FLOSS migrations. It also raises the issue of preparing the IT personnel for concepts they are not familiar with.

The social structure inside the IT department can have distinct and dynamic complexity, unique for a particular organization. Common interests may create different kinds of bonds and relationships, but people at work tend to group themselves if they share similar problems. In general, two groups inside the IT department have crucial role for the success of a FLOSS migration project: in-house developers and administrators. The motives that drive these two groups can be conflicting at times. While the developers are focused on the creative process of providing functionality in software applications, the administrators would like to have stable systems that keep running at best performance. Even though developers and administrators

express same affinity for working in teams, according to Griesser (1993) developers seem to accept changes more readily and prefer jobs that offer chance for higher personal growth, which is less the case with administrators. This finding suggests that new technology should be evaluated by developers first and after that by maintenance staff. For the technical staff to be motivated it is crucial (Wiederhold, 2003) the maintenance tasks to be highly valued in the enterprise.

The practice of sharing (Nuvolari, 2003) source code of programs is not novel feature of the software industry. Enterprise development (Augustin et al, 2002) often reflects many positive aspects of the open source community, like software and knowledge sharing and can be thought of some sort of open source microcosm, but there are differences. Building a positive attitude of the IT personnel towards FLOSS is very important for the success of the migration process. The main problem is how to prepare the IT personnel for the concept which most of them are not familiar with. Although with a long history, FLOSS is still unknown to many people (Daffara et al, 2000). Industry cases (Miller, 2004) show that developer training is the hardest part of FLOSS migration. Developers typically resist to changes in the already developed software (European Communities, 2003; Zuliani and Succi, 2004; Lederer and Mendelow, 1989; Greenemeier, 2004), many personally attach to their preferred tools and there is also a feeling of loss of power experienced by both developers and administrators. Some developers underestimate FLOSS (Lussier, 2004; Johnson, 2002).

The qualitative analysis of several case studies conducted by Lederer and Mendelow (1989) suggests that developers prefer to solve problems using old technology and methodologies. This is not much consistent with the findings of Griesser (1993) that information system personnel morale can be maintained through implementation of advanced technology. But in typical settings, IT personnel show tendency to conformism. Anecdotal evidence shows that change can be so stressful to some people (Miller, 2004), that they are ready to leave their jobs and managers have to find incentives for the majority, like buying new hardware, etc. Hodgson and Aiken (1998) point out that an individual dislikes changes in general, but may have positive attitude towards a specific change if it provides significant personal benefits. Therefore if new technology brought some kind of benefits to IT personnel, they might be willing to accept it.

The acceptance of FLOSS by IT professionals seems to be related to the personal beliefs and professional motivation. It may be difficult to persuade an IT professional to accept FLOSS instead of COTS development tools, if the individual's professional motivation is primarily based on commercial attractiveness of the profession and high wages. The acceptance of the FLOSS concept seems to be somehow related to the strongest personal motive to work in the IT field: whether it is because of financial attractiveness, or because of experiences of joy and creativeness in the profession. According to the equity theory (Joshi et al, 1986) when individuals are placed in inequitable social interchanges, they become distressed. Major reason for left jobs after a decision to migrate to FLOSS is the CV dilution effect (European Communities, 2003), when some people feel that not using "industry standard" software impairs their ability to develop their career. As Blanchard and Blanchard (2005) point out,

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employees are more likely to leave the enterprise prematurely if they are not developing their career toward their dreams.

It was described how among IT personnel there may be different reactions on FLOSS migration efforts and that developers in general accept changes more readily than administrators. Personal career development has strong impact on how FLOSS migration is accepted.

4.1.4. Influence of personal motivation

An insight into how personal motivation influences the acceptance of FLOSS migration is presented in this section. Comparison between intrinsic and extrinsic motivation of FLOSS and in-house developers is also made. Emphasis is put on job satisfaction and fun and on the need for additional incentives for retaining personnel who do not favour FLOSS.

The problems presented in the previous section are a huge obstacle for FLOSS acceptance by IT personnel in LSEs. They also reflect the differences in motivations that drive the FLOSS community and the internal IT personnel in LSEs. Seifert and Wieland (2003) explain that motivation of FLOSS developers is quite different from the one of commercial programmers. It is of crucial importance to determine the reasons behind this gap between the two cultures in order to understand how to provoke internal changes and under what conditions. Research shows (Rossi, 2004; Hars and Ou, 2002; Ye and Kishida, 2003; Weerawarana and Weeratunge, 2003) that the individual motivations of FLOSS developers can be divided into intrinsic and extrinsic.

Intrinsic motivation is very important (McHugh and Donnelly, 2004; Ye and Kishida, 2003), because it is a precondition for involvement in FLOSS projects. Intrinsic motivations (Rossi, 2004) can range from the pure joy of programming to more social-oriented motives. Based on the results of a large survey, Ghosh (2004) claims that social motivation is most important between FLOSS developers. There is also considerable evidence that altruism and knowledge sharing are also among the most important motivations of FLOSS developers since economic benefits are not significant in their decisions (Rossi, 2004; Kogut and Metiu, 2001; Bonaccorsi and Rossi, 2005; Noronha, 2005).

Motivation of IT personnel in LSEs is based on inherently different structure of incentives than the one that sustains the FLOSS community. While it was described that personal motivation is prime for FLOSS developers, the selfmotivation of developers in enterprises is hardest to achieve (Seifert and Wieland, 2003). Griesser (1993) points out that developers in organizations have lower social needs compared to other IT staff. Programming job can be very individualistic. Actually many individuals prefer autonomy (Griesser, 1993) as opposed to increased team activity. In a large organization developers are typically given very limited freedom in choosing projects and usually have to follow strict deadlines, which may be the explanation to this introvert behaviour of in-house developers. In commercial organizations some developers pay more tribute to other incentives, like economical benefits for example. This is a natural result of the different career path that people have followed in their life. People

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