An introduction of the innovation prototyping research – a position paper of the PM&RG research group

Mervi Ranta and Henrik Asplund
PM&RG – Product Modeling and Realization Group
Laboratory of Information Processing Science
Helsinki University of Technology, Finland
E-mail: Mervi.Ranta@hut.fi, Henrik.Asplund@hut.fi

Abstract

This paper gives a brief overview to the innovation prototyping research of the Product Modeling and Realization Group (PM&RG) of the Helsinki University of Technology. The methodology is being developed for the service idea generation and development of mobile and ubicomp services. The fundamental difference to ordinary product and software development is that there is no specification or straightforward source for elicitation the specification. Instead the ultimate objective is to discover features and principles that characterize the potential future needs and service ideas. Innovation prototyping iterates experimentation and analysis rounds through which a feasible basis and rationale is captured for the actual product development. Information management and modeling are the foundation of innovation prototyping and this paper refers briefly to some of the particular challenges.

1. Introduction

Information management and modeling are a main research and application area in software engineering. Obvious applications are various design and planning systems, that utilize product modeling, process modeling and document management tools. Software tools for product design and development vary according to both the design stage and application field. The stages of early conceptual design, rough sketching and detailed design set different requirements on the software tools used by the product developers. For example computer aided design of machine parts, complex software systems and telecommunication applications have to offer quite different functionality for the designers. This paper concerns the pre-product development of ubicomp and mobile service ideas. The information management and modeling interest is further constricted with the objective of supporting design and brokering of design viewpoints instead of mere documentation of the final design results.

Pre-product development refers to research, development and planning that is carried out in order to generate new service ideas and create a proper basis for efficient and successful product development. Here, the concept of service idea is used to emphasize that the development does not concern just the physical device, but rather the entire service including the service various constituents of the service provision architecture and chain of stakeholders. In contrast to mere gadget the concept of service is used to service emphasizes the functionality and added value that the user receives.

A mobile or ubicomp service is not bound to a certain gadget but may be manifested through a variety of terminals and devices. Such services are typically accessed with mobile phones, handheld computers and wearable computers. In ubicomp environments the bulky machines with technical appearance have disappeared as telecommunication and computing power has been embedded, concealed and distributed. A particular feature of ubicomp services is that ordinary objects such as note pads, coffee cups, chairs etc. have become means of ambient intelligence, augmented reality and context aware services, i.e., everyday utensils, articles, toys and accessories are extended to have magic features, allow instinctive interaction styles and offer useful services for the user.

The mobile and ubicomp service idea generation and development sets particular challenges for information management and modeling of the service and the development process. Among other things the objective is to find new ideas and potential products, i.e., the user is not yet fixed or known. Also the software development is constrained with the restrictions of small portable gadgets, service management and context awareness necessitates advanced distribution. Moreover, the development work has to allow collaboration of experts representing various fields such as software, hardware, network and usability engineering as well as marketing and content provision.

This position paper discusses the mission and interests of the Product Modeling and Realization Group (PM&RG) as an example of the activities of the Laboratory of Information Processing Science at the Helsinki University of Technology (HUT). The UML related research challenges and topics still expressed very implicitly by naming some fundamental modeling challenges. The UML research interests of the laboratory are described in another related paper written by Endre

Domiczi. This pair of papers motivates and initiates a discussion of the application challenges that innovation prototyping sets on the UML research not only at HUT but also at other entities that have similar and complementary topics.

This paper begins with the introduction of the Laboratory of Information Processing Science and the PM&RG. Then the innovation prototyping approach and methodology is explained according to its core tasks. Finally the paper gives some conclusions.

2. Laboratory of Information Processing Science

The Laboratory of Information Processing Science is a part of the Department of Computer Science and Engineering (CSE) at the Helsinki University of Technology (HUT). The laboratory carries out education and research on computer science and software applications. The responsibility areas are knowledge engineering, software engineering and software implementation techniques. Furthermore, the laboratory offers basic computer science education not only to the CSE students but also tailored introductory education to all HUT students.

The objective of the laboratory is to provide the foundation for designing, developing and analyzing software systems. This includes topics such as data structures and algorithms, programming languages, parallel and distributed systems, run time phenomena, information management and knowledge engineering. The Computer Science Education Research, Software Techniques, Data Structures and Database Systems, String Algorithms, Product Modeling and Realization, and Planning Systems Group carry out the research.

According to the objectives of science university the Laboratory of Information Processing Science takes responsibility of producing and transferring new scientific results actively for the benefit of the society. This means active research as well on programming foundations such as b-trees, string algorithms and new programming languages as on the application methods of software technologies for e.g. planning systems, ontology issues and prototyping of mobile services.

1.2.1. PM&RG research group

The mission of the Product Modeling and Realization Group (PM&RG) is development of innovation prototyping approach, methodology and tools. The operation of the research group integrates scientific research, research based education and application of research results.

PM&RG has developed the innovation prototyping methodology for the idea generation and development of mobile and ubicomp services. Thus, the objective is to provide approaches, methods and tools that suit the particular characteristics of the application field and the needs of pre-product development. The aim is to discover and anticipate the features of future mobile and ubicomp services, i.e., the target is on user needs that may rise in future, facilities of yet non-existing technologies and environments of the future.

According to the practice based research experience PM&RG proposes that particular approach, methods and tools are needed to allow proper idea generation and experimentation stages. The conventional software development and engineering methods emphasize among other things control and avoidance of risks and are therefore not straightforward applicable when experimenting and playing with wild ideas with the ultimate aim – or at least day dream – of discovering quantum leaps or killer applications. Furthermore, the generic design, design theory and creativity methods also need to be adapted, modified and complemented to meet the special requirements of mobile and ubicomp service development that include future orientation, consumer products, and turbulent evolvement of new network, gadget and software.

3. Innovation prototyping

The innovation prototyping approach has been developed for the early stage when the designers are still looking for the service ideas and their features, i.e., what kind of needs the users will have in the future mobile and ubicomp environments and what is crucial for user acceptance and for technological feasibility. Thus, the designers have to first discover the problems, requirements and service rationale that provide a ready basis for the product development process. In practice innovation prototyping iterates experimentation and analysis rounds that can be characterized by four tasks:

idea generation
experimentation planning
realization of the experimentation setting
experimentation and analysis.

The foundation of innovation prototyping lays in information management, i.e., in the development of best practices and software tools that allow capturing the design information and making accessible for the use and reuse by all the stakeholders. Here, design information does not refer to just the final design, but to all the

background information and rationale for the design decisions. Thus, innovation prototyping sets particular challenges for the modeling of the service and the related development processes.

2.3.1. Idea generation

The first task is to generate initial ideas of potential services. According to the innovation prototyping approach these ideas are allowed to rise from any possible source or viewpoint. Examples of the sources utilized in PM&RG include but are not limited to usability and user studies (e.g. interviews, observations, diaries), fiction and fantasy (e.g. scifi and fantasy literature, movies, cartoons, drama), and technology studies (new gadgets and tools, emerging technologies, basic research directions).

The crucial difference to actual product development and software production is the future orientation, which frustrates a straightforward application of conventional approaches of requirements engineering and user-centered approaches. However, it is important to notice that innovation prototyping is not prediction method and does not generate visions of the future. Thus, it must not be confused with futurology.

An essential modeling challenge of innovation prototyping is the necessity to support the viewpoints of different experts such as usability and user study, software, hardware, network, marketing and security experts. Each expert must be allowed to autonomously generate new ideas as well as plan and implement innovation prototypes. While the experts are allowed to work separately it is still necessary to broker their viewpoint models so that it is possible to combine the different models into a balanced model of the innovation prototype. The requirement of balanced brokering between different expertise means that it is not possible to utilize multiple viewpoints to a single core model. Rather, there is a need to discover and express dependencies and constraints between the different viewpoint models.

3.2. Experimentation planning

The second task is to decide the focus for experimenting the service idea. Mobile and ubicomp service development combines different viewpoints and fields that induce need for specific tests and evaluations. In spite and due to this innovation prototyping emphasizes targeting specific aspects and issues instead of attempting to test the entire complex service at once. The experimentation plan specifies and restricts the controlled conditions and procedures that ensure the fulfillment of its particular reliability criteria. Moreover, in innovation prototyping the ultimate goal of the tests and evaluations is to produce results and settings that back up and apply in future work. Each round of experimentations captures and cumulates the knowledge of features and principles that are pertinent, applicable and can be readjusted for the future development mobile and ubicomp services.

The crucial difference to actual product development and software production is that experimentation setting is the source of requirements and the reason for building the prototype. Therefore the specification of the experimentation setting precedes the design of the prototype – not to mention the realization of the prototype. Notice that this makes it necessary to be extra careful with the planning of the experimentation and capturing its rationale. The experimentation plan must not just define a valid prototype but also ensure controlled test situations and the reliability of the experimentation results.

An essential element of innovation prototyping is the design rationale approach and tools that PM&RG is developing to allow capturing the reasons and justifications of the design process. The rationale and trace of the idea generation and experimentation is the core result and the implemented gadgets and software are important proofs and illustrations related to the rationale. It is important to capture each individual development process in order to provide a basis for determining best practices, patterns and frameworks that can be utilized and reused in the development of new innovation prototypes. To ensure reliability of experimentation results and, moreover, ability to reuse parts of the experiment definition it is necessary to carefully capture the rationale of the experimentation plan.

3.3.3. Realization and experimentation setting

The third task is to realize the test setting and implement the gadgets, conditions and experimentation environment. The experimentations are carried out to recognize and verify various features and principles of future services. Separate prototypes and environments have to be realized for each experiment to fulfill its particular reliability criteria. The scale, extent, accuracy and focus of the prototype and environment realization vary according to the requirements from the experimentation specification.

The crucial difference to actual product development and software production is that the experimentation setting is build according to the requirements of the testing and not according to the requirements of the end product. Here testing does not refer to verifying and validating the implementation against the product definition, but it refers to setting up controlled conditions for reliable experimentation of certain focused issues.

A major challenge of modeling notations and practices is that they should be understandable for others than the persons that originally draw or constructed the models. In most cases the realization of an experimentation setting requires collaboration of experts representing different disciplines or fields of expertise. For example a usability test usually requires a software engineer for programming the user interface to be tested. Likewise, a hardware and network expert may be needed for implementing new interaction devices and connections that are necessary for some performance test defined by a software engineer. Thus, the experimentation plan and attached models have to support the involvement of designers that were not participating the initial design stages. A further difficulty rises from the necessity to broker the models into other disciplines that have different notation practices and put emphasis on different details.

4.3.4. Experimentation and analysis

The fourth task is the experimentation the analysis of its results. Examples include usability tests, user studies, field tests, technology comparisons, network performance and quality of service tests, security tests and privacy issue evaluations. Obviously each experiment requires expertise of the particular field or viewpoint. The development of mobile and ubicomp services necessitates such a wide variety of know-how, knowledge and skills that multidisciplinary team and expert collaboration is fundamental. The analysis and evaluation of the results is done according to the requirements and practices related to the chosen experimentation methods.

The crucial difference to actual product development and software production is that the experimentation results and in particular the possible failures, dead ends and deficiencies are valuable outcomes. This is a recognized aim of product development, however, it is even more fundamental in innovation prototyping.

Again in the analysis stage it is necessary to capture not only the interpretation results but also the rationale and assumptions of the analysis. This way it is possible to later question the analysis and to generate alternative interpretations. A deficiency of modeling notations and tools is that the model representation is often so neat and polished that the model appears to be very final and ready even when it might be even a very initial draft. Thus, the modeling tools should at least encourage if not facilitate checking and checking again the consistency of the models.

4. Conclusions

The information management and modeling methods and tools developed for conventional product development and ordinary software production are available and suit dome of the needs of innovation prototyping. However, certain characteristics of the documentation practices are crucially different.

- In innovation prototyping the documentation is created continuously during the service development and experimentation process. The designers need tools that allow the actual design and support brokering of the designs that are being created by different experts. The ordinary computerized design tools are not adequate, since they mostly are oriented for documenting the final end results and do not support dynamic changes or allow intermediate incomplete models.
- In innovation prototyping the documentation captures the actual design that includes background, considered issues, compared alternatives, reasons and even rejected solutions as well as failed experimentations. Thus, the documentation makes the design rationale transparent for all the stakeholders and gives a proper basis for reuse in later designs. This requires particular or heavily customized tools, since the ordinary documentation tools are oriented to be instructions and checklists for the programmer, maintenance personnel and customers.
- A radical clash with ordinary software development projects is the absence of specifications. The software engineers cannot rely and concentrate on validating the specification with the customer and then validating their software implementation against the specification. Rather the ultimate objective of innovation prototyping is to discover the problem by iteratively experimenting its features and related principles.

Obviously, software engineers use the existing tools and notations for illustrating, modeling and documentation, such as UML, whenever they fit the needs of some subtasks of innovation prototyping. These methods and tools provide a familiar basis for the communication among software engineers.

However, in innovation prototyping the challenge lays in communicating the notations and models to other experts such as usability engineers and marketing specialists that have not used such models and are reluctance to adapt the notations and concepts that are not related to their own field. Thus it is necessary to provide alternative views for the designers representing other disciplines. A promising approach may be to provide capabilities for mapping the models to other types of models with emphasis on revealing the dependencies and

constraints that require negotiations in order to be able to get rid of conflicts and mismatches.

The research is still going on and PM&RG is developing information management and modeling tools that are based on available tools such as modeling languages as UML, structuring tools as XML, databases and advanced document and product data management systems whenever possible.