A Definition of Convergence in the Area of Information and Telecommunication Technologies

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ABSTRACT

As the term *convergence* is heavily used in current publications, we suggest to define it as multidisciplinary, inhomogeneous integration with the aim to reach an added value. We use the convergence between telecommunication and information technology as an example to show different classes of convergence on different levels of abstraction.

Keywords

Convergence, Integration, XML, VoIP

1. THE TERM "CONVERGENCE"

Like the proverbial blind man, who touches different parts of an elephant trying to visualize the whole animal, the term *convergence* was first coined to explain a recognized phenomenon. Meanwhile it is widely used and needs to be defined more precisely. Basically the term convergence is defined as [2]:"*verb* **(-ging) 1** come together or towards same point. **2** (+ on, upon) approach from different directions. **convergence** noun. **convergent** adjective.". Based on this natural language definition of convergence we will differentiate between several classes of convergence, analyze related terms and finally give a clear definition for convergence in the area of information and telecommunication technologies.

The term *convergence* is heavily used in current publications. Referring to the new IEEE Magazine "Pervasive Computing", Satyanarayanan introduces the first issue [7] as follows:"The convergence of wireless communication and portable computers is happening before us today. [...] Something big is clearly under way. Where will it take us?". In order to analyze the term convergence in the context of technology we start by categorizing several classes of convergence on different levels of abstraction:

- Analysis, design, and architecture.
- Systems and implementation techniques: Technologies, tools and interface protocols.
- Situation awareness and point of view.
- Knowledge communities and individuals.
- Temporal convergence: Legacy integration and software cathedrals.

Apparently, several convergence processes can happen on different levels, even in parallel, and may progress differently on these levels. In addition to different classes of convergence, we also summarize several terms, which are often related to convergence:

Integration is not necessarily convergence. Assembling components homogeneously is not a convergence process on this level, but the interaction between the components may result in convergence later.

Added Value: The integration of parts (engine, transmission) can result in an added value (e.g. a car). The resulting interaction between the parts may lead to a convergence process which in turn can result in an optimization of the added value.

Innovation: Convergence can directly or indirectly result in innovation. On the other hand, innovation can also be a divergent process, resulting in something new.

Motivation: Convergence can be done actively or can happen incidentally. It can be desired or undesired. Often the search for an added value is the stimulation for starting a convergence process.

Divergence and innovation as contradiction of convergence prevent from general unification by creating new aspects.

Based on this considerations, we propose the following definition for convergence for the area of technology:

"Convergence in technology is the multidisciplinary integration of inhomogeneous methods, systems, views, knowledge areas and other disciplines of technology with the aim to reach an added value."

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2. CONVERGENCE EXAMPLES

Following our definition, the poster illustrates several convergence processes involving object oriented software engineering, databases, markup languages, the WWW, and distributed technologies including wireless and mobile voice communication. A few examples are presented here.

2.1 Hardware-Software Co-Design

Early programming with assembler languages resulted in Complex Instruction Set Computers (CISC). With the upcoming of high level languages like Pascal or C, the machine code was no longer produced by humans but rather by the backend of the compiler, which turned out to need only 20 percent of the available machine instructions. By recognizing "A computer architect builds computers to run programs" [6] the convergence of compiler backend and hardware resulted in the development of the RISC (Reduced Instruction Set Computer) architecture. The added value was a significant performance gain.

2.2 eXtensible Markup Language

XML can serve as an example for both convergence and divergence. As a result of a convergence process on the implementation level between the Hyper Text Markup Language (HTML) and the Standard Generalized Markup Language (SGML), XML combines the simplicity of HTML with the power and flexibility of SGML and is mainly used for the exchange of structured data.

Since XML is an accepted standard, many tools exist and know how about XML has broadened, XML becomes widely used in different application domains. This in turn results in a specialization, in the upcoming of specific XML representations and extensions, and divergence.

Still, XML is further involved in two other convergence processes: Object oriented software is often used to process XML data structures. Therefore, the Document Object Model (DOM) was defined to convert XML data structures into an object oriented representation and vice versa. This is also a convergence process on the implementation level with the added value of a simple, efficient and stable programming interface for XML-based software.

The second convergence process can be observed when XML data structures are made persistent in a relational database. Currently, the support for semi-structured data is improved to provide an added value for XML persistency. Moreover, pure XML databases are also under development.

2.3 Voice over IP

The convergence of the public switched telephone network and the internet is one of the most cited convergence processes in the recent past. The important added value is provided by integrated services (e.g. call center). This convergence started on the application level and resulted in a heterogenous integration of the technologies. First the data protocols remain the same and new voice protocols have been developed (innovation). Afterwards this had an impact on the data protocols in form of Quality of Service integration [3]. The convergence process proceeded via the protocol level to the systems and the concept level. This process is not finished yet.

3. RELATED WORK AND RESULTS

Although widely used in many different ways, a concrete definition could not be found. Therefore we provide some related work, which uses the term convergence in a typical way: Several papers [4],[1] describe the convergence of the Web and object oriented software engineering including the economic aspects. Mainly driven by the added value, the convergence process took place on the application level resulting in heterogeneous integration of different technologies, tools, and methods on the system level.

[5] describes the convergence of the Public Switched Telephone Network and the Internet towards the Next Generation Networks. This convergence has an impact on the hardware and the software of the network. Through open and standardized interfaces, third party applications can easily be integrated.

One of the most interesting convergence processes is just happening before us between the telecommunication and the information technologies in general. The classic methods of software engineering on the one hand have the main advantages of flexibility, fast system evolution and highly complex functionality. On the other hand the telecommunication domain provides mobile, robust real-time behavior. We can see several convergence processes – most importantly on the architecture and the concepts level – eventually resulting in a significant impact on the methods of telecommunications software engineering.

Summing it up, the added value is crucial for a convergence process. Divergence on the other hand need not be disadvantageous, because it is needed for innovation. To be prepared for future convergence processes – where they are desirable – we can provide well-defined interfaces between coherent components and use standardized or unified methods and tools. Even more so, the interdisciplinary exchange of know how and experience becomes more and more important.

4. REFERENCES

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