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Exploration Programmes:
Corporate Technology Explores Future Telecommunications

Peer-to-Peer meets Web Services: A Powerful Convergence

The telecommunications year 2001 has been dominated by the appearance of a set of new technologies, ideas and devices, which are going to revolutionise the way people and enterprises perceive interconnectivity. Among these concepts, Peer-to-Peer (P2P) networking and the Web Services architecture belong to the most promising ones. P2P – in its pure form – is basically destroying business and Web Services lead to a significant shift in the software development paradigm. The combination of the two could lead to the integration of independent single users or customers and enterprises in a harmonic system, taking advantage of the strengths of the respective model.

The Exploration Programme "Broadband Communication Opportunities" explores new broadband services and communication opportunities enabled by the new 10 Gigabit Ethernet technology, managed all-optical networks, the evolution from ADSL to broadband heterogeneous access networks (fixed and mobile/wireless) and Peer-to-Peer network models.
With its Exploration Programmes, Corporate Technology is exploring telecommunication technologies and new service possibilities with a long-term view of 2–5 years. Further, the expertise built up in the course of this activity enables active support of business innovation projects.

CHARLES CLAVADETSCHER AND XAVIER PALAU

The P2P [1] and Web Services [2] architectures have arisen from different contexts and meet different needs. While P2P addresses single Internet users and encourages them to co-operate in a particular activity, like for example file sharing or collaboration, Web Services are generic building blocks that primarily target enterprises and their software developers as consumers. The collaborative aspect in Web Services is the relation between various services, creating that way a complete application [2]. Instead, a Peer is a full-blown application that can, but does not have to, rely on external resources other than another Peer. Figure 1 shows the position and intersection of the two models referring to their degree of distribution. P2P architectures always have a high degree of data distribution. A single Peer is usually a complete application that is replicated through installation on different computers – every Peer is exactly the same, i.e. Peers co-operate in data exchange but not in activity delegation (area 2 in fig. 1). Web Services follow a different path. An application based on Web Services always has a high degree of application distribution [2]. On the other hand, data does not need to be distributed. Every Web Service handles its own particular type of data (area 3 in fig. 1), while every Peer handles the same type of data on different computers. Most interesting is the point where Peers and Web Services start to co-operate (area 4 in fig. 1). Internet consumers are constantly asking for a more flexible environment. At present the most flexible architecture is the Web Services architecture. Let us consider a Peer with a SOAP interface, i.e. able to perform and respond to SOAP requests (fig. 2). This Peer can communicate with other instances of itself on other computers, thus making up a typical P2P network. But this Peer will also be able to communicate with other Peers that perform other services in other P2P networks, or even with Web Services not implemented as Peers (fig. 3). What we will have at the end is a very high degree of integration among heterogeneous systems.

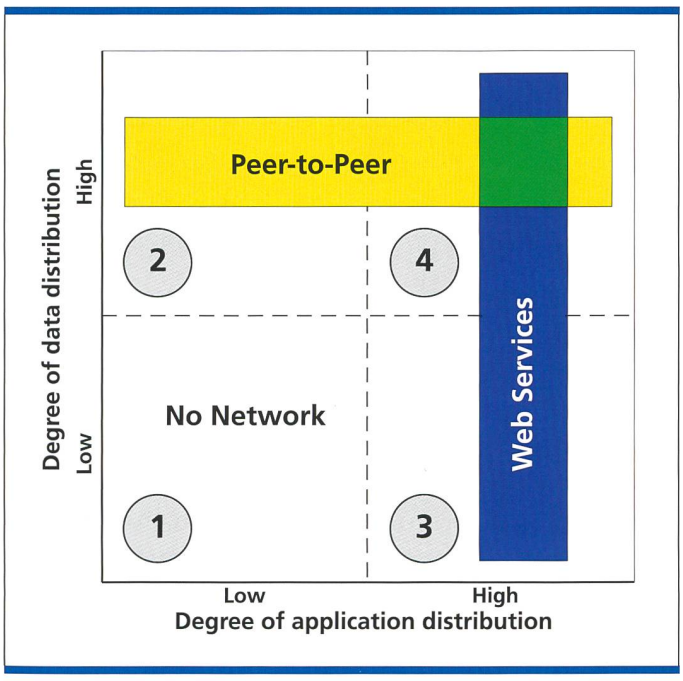

Fig. 1. Position and intersection of P2P and Web Services according to their degree of distribution.

P2P and Web Services address different needs and hence different market segments. Each is best suitable for a particular kind of technical and social environment. Finding the intersection of both and exploiting their inherent character to supply an integrated service is a big challenge with a high potential.

Brought to the highest level of abstraction we could look at this integrated environment as one single huge system, with properties that in a way remind us of a society. The Peers are the active components using a common language to communicate with each other, like people do, and Web Services are institutions offering some kind of service.
These considerations call for another shift in the way we look at software development and integration. Combining different models with different objectives requires analytical tools able to deal with an extremely high degree of complexity, like for example those found in system theory [4]. Integrating P2P and Web Services means introducing a human factor in the architecture – the user behind the Peer – which has much more freedom of action than a simple Web Service consumer.

Demonstrator developed at Corporate Technology

Our main goal was a proof-of-concept of the basic ideas exposed in this article by implementing a small prototype. We made use of two java enabled mobile phones (Motorola model A008, fig. 4). The limited memory capacity and bandwidth of these devices was expected to affect system features and was thus an additional point of interest for the investigation. At the moment of writing, the development of the demonstrator is

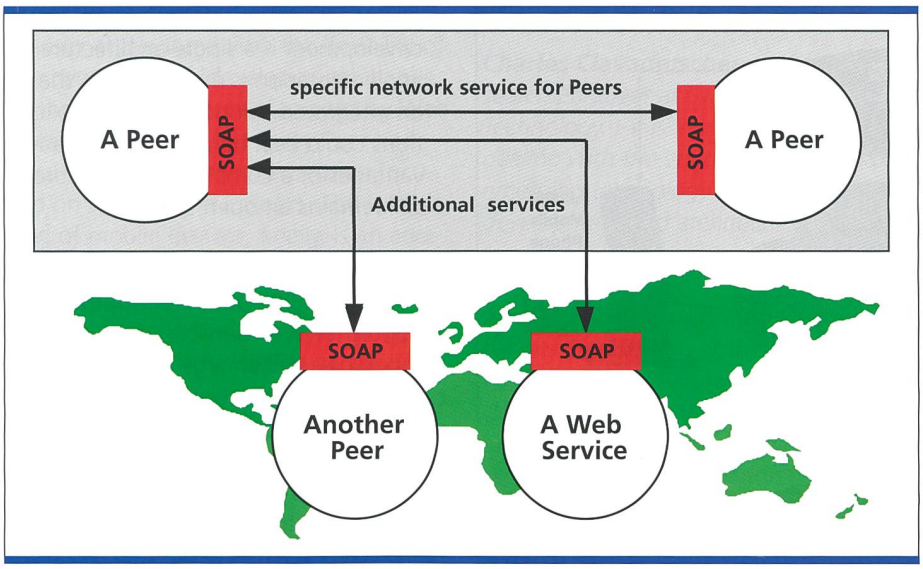

Fig. 2. A Peer with a SOAP interface can interact with any other SOAP enabled service. This increases flexibility and allows a Peer to participate in a bigger context.

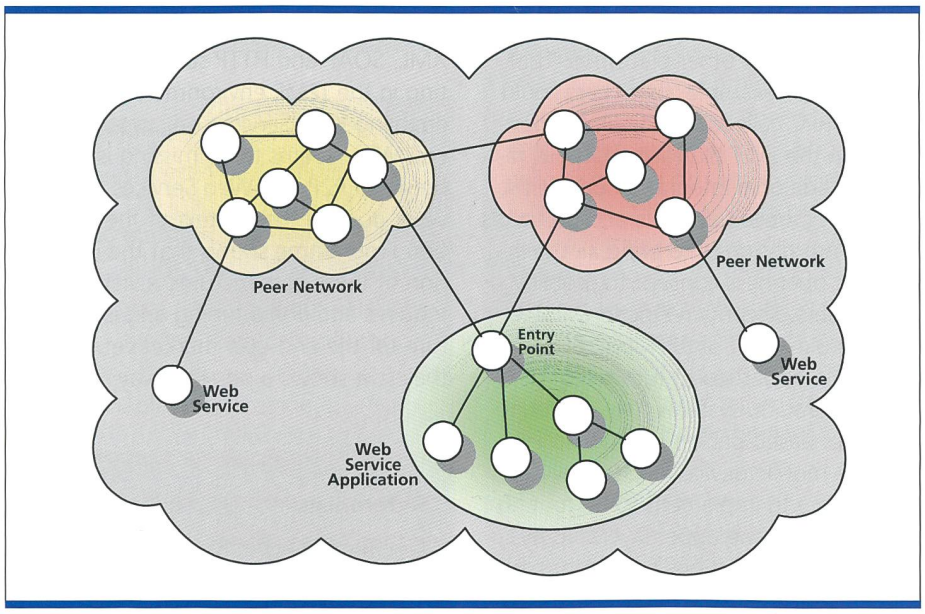

Fig. 3. Peers and Web Services can co-operate, even allowing interaction between different Peer-to-Peer networks.

fairly advanced and provides a platform for distributed phone numbers' storage and search.
The demonstrator is being developed according to the J2ME specifications, which specifically address our target type of devices and also count on growing support from device manufacturers. In this context, applications are called MIDLets, and have a particular life cycle and graphical user interface.
The application architecture includes agent Peers to provide user registration, data caching and presence information capabilities. Each mobile handset can launch a search request on the network if a phone number cannot be retrieved from the device local phonebook. A corresponding agent Peer handles this request by inspecting its internal data cache, which contains the most popular searches. Data caching can greatly improve system performance, as long as we can assume the truth of Pareto's principle that about 80% of the searches refer to only 20% of the data. If the agent's local cache does not hold the desired data, the request is forwarded simultaneously

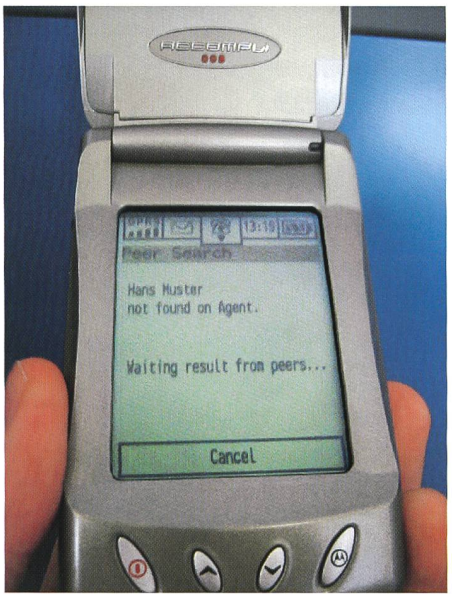

Fig. 4. A PeerDirectory instance running on Motorola A008.

to other Peers which may send the response directly to the original requester.

The Prototype Implementation

The demonstrator – code name PeerDirectory – is designed to take advantage of the P2P and Web Services architecture at the same time. That means that data is distributed among many Peers and that the real implementation of a Peer does not need to be the same on each device. The Peers communicate using SOAP, that way implementing the very first integration step between the architectures. At this point, it is possible to exploit application distribution to arrange different elements on different networks and make them collaborate in order to achieve a more enhanced system (fig. 5).
PeerDirectory in its present form still does not take advantage of Web Services, being just a P2P application in a mobile environment and thus belonging to area 2 in fig. 1. New features will be added shortly to make it a really distributed application. The first one is data caching which needs to be implemented on agents to improve system performance, but is not suitable for mobile devices. Autonomous agents will be responsible for storing other Peers' addresses through an automated login procedure, as well as for checking their availability. A second interesting feature will be the possibility to extend searches to other related Web Services when the result is not found among Peers. For instance, Swisscom's electronic

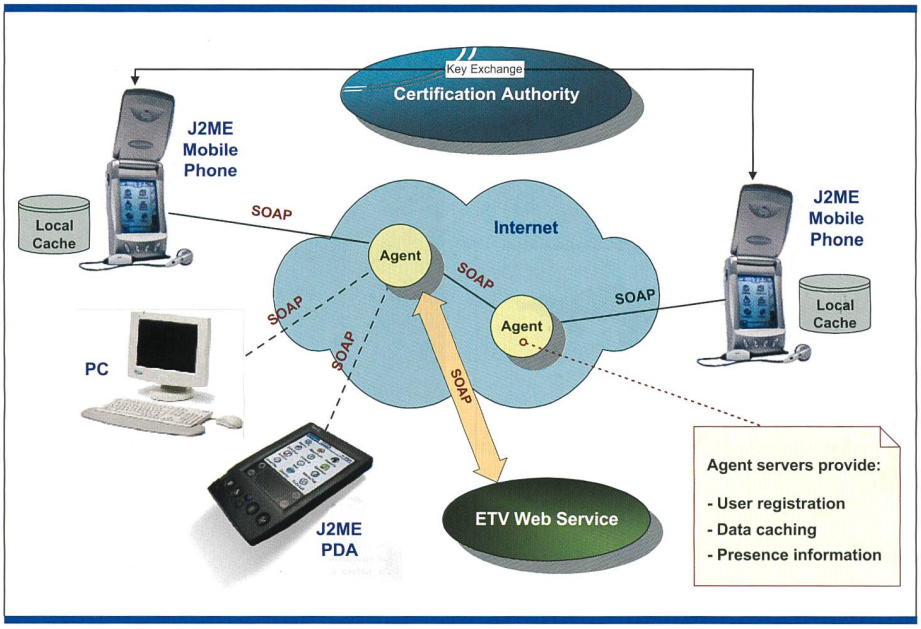

Fig. 5. The Software Architecture of the PeerDirectory application.

telephone directory (ETV Web Service) could serve this purpose. Adding a new feature to a distributed P2P application can be as straightforward as adding a new type of SOAP request and making appropriate changes on the user interface.

Conclusions

The investigation conducted at Corporate Technology led to some findings worthwhile mentioning here. In addition to the positive aspects and exciting potential of the concept, we would like to point out some possible dangers arising from the use of such an open environment as the one sketched above, without however, neglecting to mention the obvious benefits.

- The integration of P2P and Web Services architectures can be done with relatively little effort. The advantages mentioned in the previous sections make this overall concept particularly appealing.
- The fact of using mobile devices for the prototype accounted for complications not directly related to the architecture integration. The J2ME environment is quite new and does not have an optimal compliance in the hardware. Nonetheless, it was possible to state the feasibility of the main concept.
- At the moment we are still waiting for a definite SOAP standard. Based on the promise of platform independence through XML we expect no particular problems of compatibility with implementations on other platforms. That means, for example, that Peers could make RPC calls to services implemented on the .NET platform, without facing traditional integration problems.
- Present mobile networks and protocols were not designed to bring all the Internet openness concept to mobile end users. Security restrictions make the deployment of P2P applications difficult. In particular, firewalls and IP masquerading systems may challenge IP-layer based packet routing. To enhance mobile device reachability it is necessary to implement some routing solutions on the upper layers. To bypass these restrictions new ideas have been developed like Relay-Peers (also called Router-Peers or Rendez-Vous-Peers). Web Services basically tunnel their requests through HTTP, bypassing security as well. It will be mandatory to consider security aspects at the application level in software development in order to avoid large-scale abuse.
- The use of standard protocols reduces the control ability of service providers. This implies that enterprises with a business focus on P2P and Web Services may have to rely on cryptographic techniques to allow access to system resources. Authentication and measurability of use may become a major threat to the expansion of this model, since customers demand simplicity.
- The integration model introduced here opens new opportunities. It is however necessary to investigate for each new development if a single-architecture implementation is more suitable than an integrated solution. Which applications could best benefit from the advantages of a combined architecture still remains an open question.

Outlook

As Gartner points out in ref. [3] the "support for Web Services and mobile technologies will emerge as the next focus for technology-aggressive early adopters". What Gartner sees as a trend up to 2003 is pursued today at Swisscom Corporate Technology. But we are not the only ones to consider integration of P2P or Web Services with other technologies as a major concern in future developments. Sun Microsystem is moving with its JXME projects towards allowing easy implementation of P2P applications on mobile devices. Enhydra is releasing a set of java micro implementations for XML, SOAP and HTTP suitable for operating in the J2ME environment, de facto enabling Web Services on portable devices. What seems to be missing is the link between P2P and Web Services. The work done in the context of the Exploration Programme shows that the integration of these architectures is viable, but requires additional tuning and is not mature for the end-user market yet. Nonetheless it shows a possible way to reduce

References

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[2] Messmer Bruno, Keller Rico, Clavadetscher Charles: "Web Services: A New Paradigm in Software Architecture", comtec 7/8 2001

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[4] Ninck Andreas, Bürki Leo, Hungerbühler Roland, Mühlemann Heinrich, "Systemik: Integrales Denken, Konzipieren und Realisieren", ISBN 3-85743-994-7

the business threat of pure P2P and increases at the same time the flexibility of the overall system development, thanks to the open interfaces as implied by Web Services. Concepts like Relay-Peer and Router-Peer add a new dimension focused on security and its leaks. The integration of mobile devices, finally, is an additional challenge that opens new horizons. Corporate Technology will keep a close look at the business opportunities offered by the orchestration of valuable ideas such as P2P and Web Services, embedding its results in the Swisscom view of future technology and business. [10]

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Links

Project JXME homepage:
jxme.jxta.org

Enhydra homepage:
www.enhydra.org

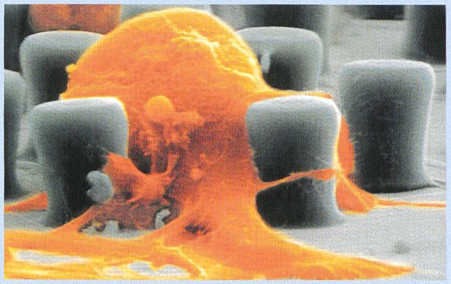
Abbreviations

HTTP	Hypertext Transfer Protocol. The Internet standard for requesting and retrieving files in the World Wide Web
J2ME	Java 2 Microedition. The Sun Microsystem's specification of a Java Virtual Machine able to operate in an environment with limited resources, such as most portable devices.
P2P	Peer-to-Peer. A software development principle and architecture detailed in [1]
RPC	Remote Procedure Call. A function call made from one computer of a function residing on another computer.
SOAP	Simple Object Access Protocol. A proposed standard for RPC using XML over HTTP and for serialising and deserialising data.
XML	Extensible Markup Language. A new standard allowing everybody to define his own set of markup tags, i.e. formatting delimiters enclosed in brackets and following a defined syntax convention.

Zusammenfassung

P2P und Web Services sind unterschiedliche Architekturkonzepte, die entsprechend auch verschiedene Bedürfnisse abdecken. P2P-Applikationen orientieren sich an einzelnen Benutzern und delegieren ihnen einen Teil der Verantwortung über die Verwendung von Bausteinen. Web Services sind solche Bausteine eines grösseren Systems, die heute dazu verwendet werden, um Server-Applikationen zu erstellen. Der Versuch diese beiden Architekturen zusammenzubringen, bedeutet mehr als die Summe der Einzelkonzepte. Das Endergebnis ist eine sehr flexible und offene Platt-form. Damit sind aber auch potenzielle Gefahren verbunden. Durch das Delegieren eines Teiles der Verantwortung an Benutzer, die sich nicht mehr als reine Kunden, sondern auch als aktive Komponenten eines Systems sehen, wird eine schlecht kontrollierbare und voraussehbare Grösse im System eingeführt: der Mensch. Dadurch wird es vermehrt nötig sein, analytische Mittel der Systemtheorie anzuwenden, um diese Systeme zu verstehen und zu steuern. Welche Auswirkung von dieser Gesamtentwicklung zu erwarten ist, lässt sich demnach nur schlecht abschätzen.
Dabei zu sein stellt aber eine aufregende Herausforderung dar.

Auf dem Weg zum Neurochip



Nervenzelle auf einem Siliziumchip.
MPI für Biochemie

Auf Einladung des IEEE sprach auf dem International Electron Devices Meeting (IEDM) 2001 in Washington D.C. der deutsche Wissenschaftler Professor Dr. Peter Fromherz über seine Arbeiten an der Synthese von Halbleitern und synaptisch vernetzten Neuronen. Peter Fromherz arbeitet am Max-Planck-Institut für Biochemie in Martinsried bei München und gilt als der weltweit führende Forscher auf diesem Grenzgebiet. Ein kürzlich an seinem Institut gemachtes Mikrofoto zeigt eine Nervenzelle auf einem Siliziumchip, die durch sechs Kunststoffpfosten «eingezäunt» ist. Wird die Zelle durch einen Spannungsstoss über den Feldeffekttransistor unter ihr erregt, dann leitet sie dieses Signal über synaptische Kontakte an benachbarte Nervenzellen weiter. Deren Aktionspotenziale lassen sich dann wiederum über einen Transistor messen. Mit diesen Experimenten wurde der Einsteig in die «Neuroelektronik» vollzogen.

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Leiter vibrieren unter Strom

In einem spektakulären Versuch gelang dem Energieversorgungsunternehmen Tokyo Electric Power erstmalig der Nachweis, dass Elektrizität in einem Leiter diesen zu Vibrationen anregt. Diese Vibrationen sind doppelt so schnell wie die Frequenz des Stroms durch den Leiter. Mit Hilfe von Reflexionen gelang es, diese Vibrationen für das menschliche Auge sichtbar zu machen. Jetzt will man daran gehen, den Versuchsaufbau stark zu verkleinern, sodass schliesslich ein handliches Gerät herauskommt.