3. Deployment in an orchestration engine. Business process execution technologies have proven successful when applied to coordinating networked services, especially in Service-Oriented Architectures (SOAs). We have extended these technologies, which have already been applied in the 'traditional' Internet, and applied them to the Internet of Things. In particular, we have developed middleware for integrating automatic identification technologies such as RFID or QR codes with business process execution engines based on WS-BPEL (Web Services Business Process Execution Language).
4. System reconfiguration. A model-based reconfiguration engine is used to automatically adjust the system architecture to the requirements presented as models. To achieve this, the system architecture is based on components and communication channels that can be dynamically established among them for achieving a particular behaviour. In this way, a service can transit from silent behaviour to behaviour that is noticeable by the user as a reaction to the business process evolution.

This work is part of a four-year research project at the ProS research centre, which is devoted to the development of new methods for the production of software in different areas. The techniques presented here have been successfully applied to scale environments with real technology in our research lab, with the measurement of acceptance by real users being the next step in our research.

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An Autonomic Home Networking Infrastructure

by Thomas Luckenbach, Mario Schuster and Marc-Oliver Pahl

Next-generation home networking environments will contain a variety of Internet-ready devices or embedded systems, which will result in increased complexity for the end user. New methods are therefore required to build autonomic networking infrastructures that enable auto-configuration and self-management of the networked elements and keep technical details hidden from the user.

In future Internet-based home environments a variety of devices such as PCs, smart phones, networked appliances and embedded systems will be organized into infrastructures and will act together to form a new type of service provisioning platform. Today's typical home environments often contain a few of these Internet-ready devices; in the future there will be even more, including embedded systems like sensors and actuators that are also accessible via Internet technology (eg TCP/IP, HTTP, Web services etc). While on the one hand this gives users the freedom to access a rich variety of devices in the vicinity of their homes, on the other it increases the depth of knowledge required to understand what is happening in such a complex networking environment. Novel methods for autonomous networking as well as self-configuration, self-management, self-organization, self-protection and self-healing (self-x) of the networking elements can take responsibility for observing and controlling the home network without directly involving end users.

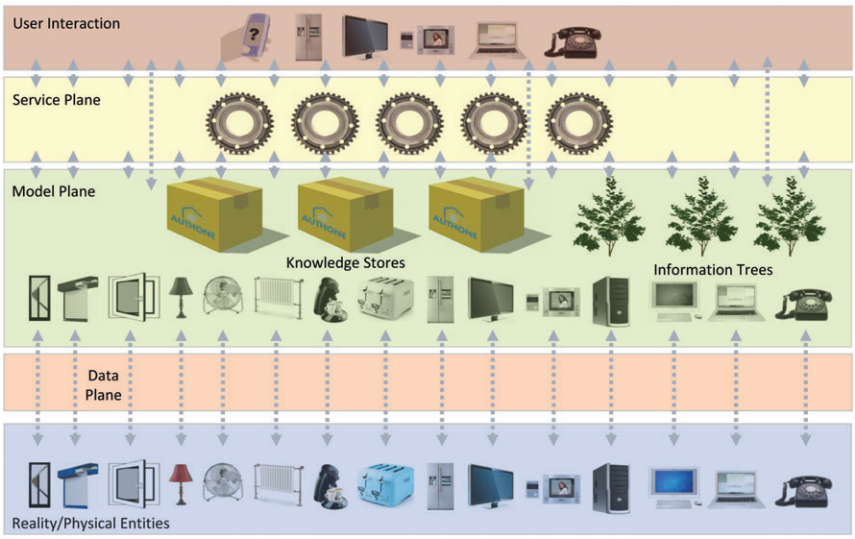

Figure 1: Hierarchical three-tiered architecture for modelling and using knowledge in a home network environment.

For this purpose, the German national project Autonomous Home Networking (AutHoNe) has been started in 2007. The main goal of the project is to enable autonomous networking technologies in home and industrial environments. The project takes into account a variety of currently available or future technologies that can operate in those environments. Another aspect of AutHoNe is to provide users with a consistent and transparent view and approach to accessing information and services in the home. This includes the development of mechanisms for the intuitive definition of rules, constraints and other parameters that influence the autonomous behaviour of the networking elements.

AutHoNe introduces a hierarchical concept, whereby low-level devices and communication protocols are integrated into a high-level scheme that is capable of executing so-called knowledge services to observe the entire network, and a collaborative decision-making process

based on the gathered knowledge of the network. This also includes redundant behaviour of the services as well as the ability to distribute rule and profile descriptions within the network.

For this purpose, the different information and data structures coming from the low-level networking elements - which are often completely different and proprietary - must be adapted to a unified knowledge model to ensure that the autonomic methods of the knowledge services can operate in a generic and technology-independent way. AutHoNe therefore defines a three-tiered approach (see Figure 1) that includes:

- a data plane representing the basic information coming from the basic network elements at the bottom layer, as well as communication not addressing the AutHoNe framework (eg non-control information like video streams etc)
- a model plane representing the high-level abstraction of the information as mediator layer
- a service plane as top layer enabling the autonomous control of the network based on the knowledge abstraction.

The knowledge model is defined through state-of-the-art description techniques (eg XML) containing basic information of the network elements as well as rule and profile descriptions and meta-information. An important requirement is that the knowledge model is available to all nodes in the network that run knowledge services in a distributed and redundant way. All the AutHoNe services operate on the modelled world. Since services have models too, they can be puzzled together in many different ways allowing service providers to mash up their services from other services. The selection of adequate protocols for the communication and model and knowledge representation is still in progress. Our model-centric design could be the key for a future home network rich in useful services that can be provided as easily as iPhone applications are today.

Another important issue is the adaptation and integration of the information coming from the low-level networking elements to the knowledge model. For instance, IP-based devices can provide information about their capabilities and their state through typical network management protocols (eg Simple Network Management Protocol - SNMP). Embedded systems like sensors or actuators can provide information though other methods (eg ZigBee profiles, SensorML/TransducerML descriptions, or IEEE1451 data sheets). Ongoing work in the AutHoNe project will consider these approaches and implement suitable adaptation mechanisms in order to support current and future technology embedded in an overall knowledge-based home-networking infrastructure.

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Load-Balancing Energy Usage of Household Appliances

by Lennart E. Fahlén

The combination of ambient/ubiquitous interface technology and Internet-based energy load-balancing tools with a consumer focus, holds promise for increased energy savings and control.

Informed consumers save energy

Incentives to be energy-aware are increasing on many levels: economical, social, political and environmental. We know that consumers want to save energy if they can, and studies show savings between 5-15% can be achieved simply by providing direct feedback. However, when it comes to managing energy usage in the household, today's consumers are pretty much left to find their own solutions, such as reading electricity meters and using timers to switch equipment on and off. To address this, the new concept of the 'Internet of Things' provides promising ways to integrate the control of energy into everyday life without the need for drastic lifestyle changes. Computer technology makes it possible to transform complex information into a more accessible form, resulting in improved consumer energy awareness and control and assisting consumers in reducing energy usage.

The load-balancing mechanism

Shifting electricity usage (by time and space) is a desirable goal for many energy-saving initiatives. A further goal is to explore the possibilities inherent in aggregating energy usage into cooperating pools for load-balancing purposes. Pooling usage and reducing peak loads allows an aggregation of use with the potential, for instance, to negotiate lower average rates (possibly offset by higher peak load rates at the margin).