

# MIDDLEWARE INTEGRATION PLATFORMS: A NEW CHALLENGE TO BUSINESS MODELS OF ICT COMPANIES

## *Unleashing the Business Potential of Horizontalization*

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**Abstract:** Information and Communication Technology (ICT) has the potential to transform business on different levels. Changes in the ICT market, the technology and its dynamics, and of customers' demands and needs will challenge the current business models of ICT companies. If middleware integration platforms integrate presently isolated networks, organizations may have to re-define their role and their business scope; especially if the assumptions hold true that middleware platforms foster disintermediation and enable new players to enter the market. In this paper, the business potential of reusing sensing, actuation and processing services for different applications - termed horizontalization - is described. It provides insights to the design and architecture of middleware integration platforms designed to enable horizontal services and gives examples of e-business opportunities that can be realized on top of middleware integration platforms.

## 1 INTRODUCTION

In the early stages of the Internet it was primarily considered as an additional information channel. It took some time before companies realized the potential of the Internet to increase efficiency: the Internet enables transformation of business processes and business networks, and eventually even business scope redefinitions (Venkatraman, 1994). The evolution of the Internet has still not come to an end and latest advances in Information and Communication Technology (ICT) extend the Internet's business potential. One of the next evolutionary steps is assumed to be the bridging of the physical world with the digital one by the means of recent innovations in the fields of (Wireless) Sensor and Actuator Networks (WSAN), Radio Frequency Identification (RFID), Machine to Machine (M2M) data communications, positioning systems, and Network-Embedded Devices (NED) (Presser et al., 2008). Vertically integrated and

closed solutions on the basis of WSANs, RFID and M2M are already deployed for various purposes. Middleware integration platforms now aim at integrating information from different sources, which means that they approach to combine vertical solutions that were originally designed for a single purpose. In comparison to so-called vertical solutions (built for a single purpose), we term the concept of reusing services in a uniform manner - such as sensing, actuation and processing services - *horizontalization*. In this way, the speed of business transformation could increase, as the reach of the Internet is extended to the real world and its potential can be realized on a global inter-organizational level. Information is not just an auxiliary factor that supports the production and shipment of physical products; it is even a product of its own in electronic platforms that enable the processing of information, communications and transactions. The evolution of the Internet may enable new e-business opportunities and new business models, which can generate new value. E-

business opportunities can be of different nature, e.g. Business-to-Business (B2B), Business-to-Consumer (B2C), administration to business, or intra-organizational (e.g., Amit and Zott, 2001; Timmers, 1998); this paper focuses on B2B and B2C.

The purpose of this paper is to foster the understanding of the business potential of horizontalization. Therefore, future directions of the Internet and a prime example of a middleware integration platform that aims at realizing the concept of horizontalization are described in section 3. Concrete e-business opportunities on top of such a middleware integration platform are depicted in section 4. Section 5 is dedicated to implications of the concept of horizontalization and the deployment of middleware integration platforms. These implications suggest a challenge to the business models of ICT companies and may help managers and strategists to anticipate a redesign of business processes and networks and eventually even the overall business scope.

## 2 METHODOLOGY

The research questions were: (1) how should a middleware integration platform be designed and how does it work? (2) Which e-business opportunities may emerge on top of a middleware integration platform? (3) What implications on business models arise from the deployment of middleware integration platforms and especially the concept of horizontalization?

As we found little research has been done that combines the aspects, in which we want to investigate, and a comprehensive understanding of those aspects seems missing in the current literature, a qualitative research method was applied (on basis of Bryman and Bell, 2007). The research approach was divided into two parts: the design of middleware integration platforms and the assessment of e-business opportunities that may emerge on top of those platforms were investigated within the framework of the research project SENSEI ("Integrating the physical with the digital world of the network of the future", SENSEI, 2010a). We conducted 25 interviews to assess design principles and business opportunities of middleware integration platforms. The interviewed organizations were ICT businesses, to which the SENSEI approach may become relevant; this particularly includes: infrastructure providers, service developers, and service providers. We identified key personnel in charge of future strategy, experts in Future Internet and WSAN research as the valuable contact persons

and potential interviewees. The expert interviews have been conducted via phone or face-to-face and followed an interview guideline. The other part of our research approach went beyond the SENSEI project: a literature review was performed, which was followed by another round of in-depth expert interviews. Eight semi-structured face-to-face and phone interviews were conducted with managers and strategists to foster the understanding of how middleware integration platforms and especially the concept of horizontalization would challenge their business models.

## 3 MIDDLEWARE PLATFORMS

This section describes related work and the results of a literature review about future directions of e-business and it presents the SENSEI framework as a prime example of middleware integration platforms. We validated SENSEI's design by 25 in-depth expert interviews.

As the Internet evolves e-business services can become more and more sophisticated. One of the most important drivers of the Internet's evolution is its extension of reach to the real world: innovations that aim at connecting the physical with the digital world in a network of objects are commonly termed the "Internet of Things" (IoT; cf. e.g. Floerkemeier et al., 2008). ReadWriteWeb (2009) provides a good overview of recent IoT products. Recent ideas picture the IoT as an "encompassing vision to integrate the real world into the Internet" (Presser et al., 2008): also referred to as the Real World Internet (RWI). The RWI dimension and other concepts such as the Internet-of-Services (Buxmann et al., 2009) are parts of the so-called "Future Internet" (European Future Internet Portal, 2010; Presser et al., 2008). The evolution of the Internet and especially the RWI dimension of the Future Internet are only possible due to advances in ICT such as the emergence of WSANs, RFID, M2M data communications, positioning systems and NEDs. These technology developments are considered to be enablers of the vision of an all encompassing infrastructure that bridges "the realms of bits and atoms" (Greenfield, 2006). Many researchers are about to push the evolution of the Internet forward, especially by contributing to the realization of the vision of the RWI dimension of the Future Internet (4WARD, 2010; Beecham Research, 2008; EU-MESH, 2010; Haugli, 2009; ISSNIP, 2010; Pachube, 2010; SENSEI, 2010a; Socrates, 2009; uID Center, 2010; WiSeNts, 2006; and many more).

Most interviewed experts and researchers agree with Haugli (2009) on the assumption that there will be a shift “from closed vertical solution to open horizontal layered value chains”.

Among the research activities that design and develop technology platforms, the SENSEI project (SENSEI, 2010a) is outstanding as it is the biggest Integrated Project from Call 1, Challenge 1.1: “The Network of the Future” with an effort of about 1900 person-months and involvement of 19 consortium members from eleven European countries. The SENSEI framework aims at “integrating the physical with the digital world of the network of the future” (SENSEI, 2010a). To make this vision become reality, sensors, actuators, and NEDs have to be deployed everywhere and interconnected. Indeed, WSANs are already deployed on a noticeable scale. However, almost all of them are currently used for single-purposed vertical solutions. Horizontalization is therefore the key design goal of the SENSEI framework, which means the reuse of sensing, actuation and processing services for different applications. The open, business-driven architecture of the SENSEI middleware platform integrates heterogeneous WSANs and provides uniform access to RWI service components. SENSEI services like discovery services or query services enable the development of e-business applications on top of the middleware (Figure 1).

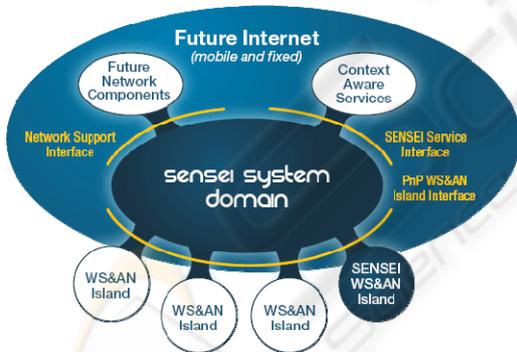


Figure 1: The simplified SENSEI framework.

The SENSEI architecture is designed in a way to satisfy the demands of multiple players in an evolving Internet value network and therefore addresses several aspects, amongst others: privacy and security (protect the privacy of users and offer adequate security for participating systems and entities being observed and acted upon), accessibility (reduced complexity of accessing sensing and actuation services for applications), scalability (support efficient internetworking of a large number of distributed sensor networks islands),

heterogeneity (accommodate a variety of sensor and actuator networks with different technology and administrative domains), manageability (permit distributed management of participating systems and resources), and simplicity of participation (ease the integration of new WSANs) (SENSEI, 2010b).

The horizontal architecture of the middleware platform should enable the reuse of real world services in a uniform manner, which is realized by the means of standardized resource descriptions and flexible service composition. The platform should offer one modular framework with real world services at different levels: on the first level, there are basic sensor and actuator access services, on the second level, basic discovery or sensor and actuator services are offered, the third level, should provide real world context and actuation management services, and on the fourth level, there are dynamic real world service instantiation and composition. The integration platform may have the ability to create a business ecosystem with different players offering any subset of those services. The architecture even allows small providers with low-value transactions to join the framework. This will create new e-business opportunities and contribute to bridging the gap between the net and the real economy. The interviews revealed that the stakeholders expect the concept of the middleware integration platform to enable innovations, support the innovation dynamics within companies, and lead to changes in the market.

## 4 E-BUSINESS APPLICATIONS

On the basis of the concept of horizontalization, middleware platforms like SENSEI that aim at integrating formerly separated WSAN islands and incorporate M2M data communications have the potential to enable or at least improve a variety of e-business applications. On the basis of such middleware integration platforms, both B2C as well as B2B e-business applications can run, providing business opportunities in different service sectors like retail, public transport, asset management, building automation, smart grid, emergency management, healthcare, or automated manufacturing. Only the application domains asset tracking, building and home, and entertainment can be presented in more detail in this paper.

### 4.1 Asset Tracking

The need of middleware integration platforms

becomes particularly obvious in supply chains, where goods flow through different organizations, each with its own information system. Current supply chain infrastructures are limited to RFID and barcode technologies and do not yet include sensor data on a large scale. Middleware integration platforms aim at enriching current applications with sensed physical data from various entities and can thus enable e-business applications to reduce delivery delays, improve compliance, secure product delivery to consumers, reduce loss or theft of goods, minimize waste, reduce the extent of management-by-exception, allow ongoing real-time analysis, and ensure supply chain integrity. E-business applications for asset tracking on the basis of middleware platforms are especially motivated by the anticipated achievement of the business benefits: efficiency and quality, and supply chain integrity.

*Efficiency and Quality:* Sensor data on transportation can enormously improve the efficiency and quality of the underlying business processes as sensors can contribute to full visibility of the supply chain. This allows companies to know exactly where their products are, to analyze ongoing processes, and thus to continually redesign processes and norms. Knowing about products' location and conditions helps to reduce delivery delays as well as to identify and eventually reduce loss and theft. Waste can be minimized, for instance, if the ripest product can be delivered first. For companies this means that fewer products need to be discarded, which leads to lower cost. Moreover, existing infrastructures are limited when it comes to reacting upon deviations between real world data and plan data. Middleware integration platforms that combine WSAWs and enable M2M interactions could be designed in a way to immediately trigger actions (via actuators) to counteract deviations between real world data and plan data. Companies can implement proactive processes that are triggered by actuators and thus become a proactive instead of a reacting organization.

*Supply Chain Integrity:* During the products' flow through the supply chain, companies are faced with compliance requirements, like external regulations imposed by external authorities (e.g., legal, tax, and transport), environmental (e.g., waste electrical and electronic equipment guideline) or social regulations (e.g., business code of conduct). Compliance with these rules in an economical way is essential for companies' competitiveness. The ability to seamlessly trace supply chain integrity protects consumers from rotten food or flawed medicine and gives manufacturers the proof of compliance. Transports sometimes require that

shipments get consolidated into cooled trailers with temperature registration. The information from recent temperature registering devices was only available after the trip. Now, middleware platforms can gather real-time information about current state, location or temperature via sensors that are deployed throughout the supply-chain in order to compare that data with compliance-based planning data and to detect deviations between the 'to be' and the 'as is' state. In case of critical deviation, information systems that are connected to WSAWs can initiate appropriate actions to re-establish the supply chain integrity and to prevent further implications of the deviation.

## 4.2 Building and Home Automation

In the building and home automation application sector an increasing number of objects can be monitored, like water, gas, and electricity consumption or automated, like heating, lights, shutters, or blinds. Innovations such as automatic collection of consumption and status data from metering devices are commonly termed as "Advanced Metering Infrastructure" (AMI). The combination of data from AMI with sensor data, e.g. presence of people, and data from information systems can facilitate various e-business applications. Middleware integration platforms can gather the data that organizations need to integrate from different vertical solutions, share information with other parties, and eventually outsource non-core infrastructure and thus lower cost (see also Haugli, 2009). E-business opportunities are mainly related to applications that help to reduce energy and cost as well as to increase security.

*Consumption and Cost Reduction:* Recent developments in miniaturization of sensors and actuators and lower prices for bandwidth have increased the potential for integration of different systems: e.g., plausibility checks decrease the number of false alarms, integration of weather forecasts with heating systems reduce energy use. Reduction of energy is especially important in places where people are not too concerned about energy billing as in offices or in public buildings. A probably well-known example of reducing energy is to combine information from a calendar about occupancy of a meeting room with the central heating and lighting system. Temperature and light only need to be convenient in times of meetings in that room. Consumers may benefit from better notification and control of consumption. Concerning water and energy they could realize the concrete consumption of a washing machine and they can be

informed about leakage, waste, or malfunction use, e.g. in toilets.

*Increased Security:* The integration of AMI and WSAN data into one middleware platform can help to detect leakages. Water or gas leakages are difficult to detect because most tubes are underground. The detection of gas leakage is especially important to happen in real-time for security reasons. The integration of data may also help to notice a loss of electricity. Electricity theft occurs in slums of big cities and creates safety risks, e.g. fire or blackouts caused by short cuts.

### 4.3 Entertainment

In Western societies many people spend a lot of time in entertainment activities such as sports and video games as well as money on equipment and accessories. Consumers seem to appreciate new applications like new games or personalized training programs. A key adoption driver for middleware integration platforms is the fact that several sensors are already deployed for other purposes, e.g. weather forecast, in urban areas. The integration of and ubiquitous access to sensed information of different kind and the connection to information system can pave the way and add value to sophisticated mass customization services. Modern e-business services may satisfy two major customers' needs and wants: real-world assistance and greater amusement.

*Real-world Assistance:* Integration of sensed information and services like geo-positioning into a middleware platform together with connections to information systems, allows e-business applications to be implemented that users can be supported when moving through unknown cities. Weather forecasts, notifications about traffic jams, or write-ups from other users and recommendations that pop-up in real-time when passing by, might become applicable on cell phones to ease the get along and enrich the experience of visitors. Training plans may be aligned with weather forecasts and modified, e.g. if the air pollution level is too high at the initial planned training session.

*Greater Amusement:* Video games may be extended to the real world, e.g. scavenger hunts on cell phone based on geo-positioning services.

## 5 IMPLICATIONS

The deployment of middleware integration platforms and the realization of horizontalization may have different implications on business:

*Application service providers and WSAN owner can address a broader market:* application providers who base their services on top of a middleware platform can compose more sophisticated applications by consolidating information that stem from formerly disconnected networks like WSAN islands (cf. Figure 1). Currently, WSAN are mainly deployed for single purpose use and provide only some niches with data. Through the connection to a middleware platform, single sensing, actuating, and processing services from WSAN islands can be reused for multiple services.

*New business roles may emerge:* at the moment no "sensor data repository" exists. A new role may be the one of a sensor information broker, some kind of "Google for sensor data", who pre-collects information, caches and re-sells it. The revenue generation mechanism may work by pay-per-use. A similar new role could be a kind of apps store that offers a platform on which new applications can be developed and bought. The business model could imply an open innovation approach, similar to the one of Apple's iPhone apps store.

*Rivalry among competitors may increase:* Middleware platforms that aim at integration on a global scale provide business opportunities to competitors worldwide. In accordance with Porter (2008) rivalry will increase due to: (1) augmented bargaining power of customers because of higher transparency. Consumers gain ever more transparency about advantages and disadvantages of providers as well as about the quality of services. Internet forums and blogs foster this development, (2) threat of substitute products and services, because higher penetration of mobile services, emerging technologies, and paradigm shifts will provide new product and service possibilities, (3) bargaining power of suppliers, as increased volumes but falling prices may encourage suppliers to cut out intermediaries (disintermediation) or at least strengthen their bargaining power, especially if middleware platforms facilitate direct connections between business partners, and (4) threat of new entrants as the architecture of middleware integration platforms allows small providers with low-value transactions to join the framework.

## 6 CONCLUSIONS AND OUTLOOK

The sketched implications may challenge the business models of ICT companies as changed assumptions about the environment of an

organization entails changes to the “Theory of the Business” (Drucker, 1994). In the context of middleware integration platforms being deployed and presently isolated networks being integrated, organizations may have to re-define their role and their business scope. It will be a challenge for ICT organizations to assess which business opportunities will generate revenue. This will depend on the attitude of consumers and their willingness to pay for the services, as well as on how middleware platforms will be implemented. Future research is necessary to identify business opportunities that really pay off and to define the companies’ roles within a value network in which the concept of horizontalization is realized.

Further challenges and future research topics include: first, the assessment of the extent to which businesses are willing to apply WSN and M2M technology. Incentive schemes might need to be elaborated to get everyone involved who is required. Second, companies must be empowered to share information via middleware platforms. Risks, which go along with the inter-organizational sharing of data must be identified and minimized. Third, standardization and interoperating among devices is needed. On the one hand, it is important to enable consumers to easily plug in devices and on the other hand it is a prerequisite to reap business benefits due to economy of scales. Fourth, security and privacy aspects must be taken into account. The privacy of users must be protected and the adequate security mechanisms must be provided for the participating systems and entities being observed and acted upon. Approaches and solutions to these research topics will foster the evolution of the Internet and extend its business potential.

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