# A Networked Ubiquitous Computing Environment for Damage Prevention

## A Decision Support Framework for the Insurance Sector

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*Abstract*— **This paper focuses on identifying and analyzing a potential innovative application for the insurance industry through the use of networked ubiquitous computing environment. In particular, it will describe damage prevention as an exemplary application of ubiquitous computing in the insurance sector. With respect to such an implementation for damage prevention, this paper presents a framework for decision support, considering cost drivers, indicators, parameters, and other influencing factors.**

***Keywords-component; monitoring system; case study; insurance sector; ubiquitous computing; decision support***

## I. Introduction

Current advances in hardware miniaturization, the continuous increase in communication, processing and storage capabilities as well as the proliferation of electronic devices will create a ubiquitous computing and networking environment in which anything will be accessible at anytime from anywhere by anyone. This innovation potential has slowly emerged within traditional manufacturing, distribution and retail industries, and as of yet had limited exposure in the financial services industry, in particular the insurance industry.

Identifying and analyzing the potential of ubiquitous computing in the insurance industry, this paper particularly focuses on damage prevention as an exemplary, promising application. More precisely, this paper presents a framework for decision support in the insurance sector, providing indicators, parameters, and influencing factors to be considered for feasibility studies, risk management, and monitoring during live operation. Innovation cycles accelerate [1, 2], prices, rebates, customer behavior, etc. undergo a permanent change. Insurance companies have to include all these factors in their risk calculation and monitoring endeavors, for which our framework shall provide guidance.

## II. Ubiquitous Computing

### A. Characteristics

Ubiquitous computing aims to minimize the gap between the physical and the digital world, by envisioning that every object will be outfitted with an embedded computing device. This allows any object to identify and transmit information about them creating a certain ambient intelligence. Various definitions for ubiquitous computing exist, the following characteristics were agreed on by the research community [3]:

- Ubiquitous Computing deals with non-traditional computing devices. In other words, it focuses primarily on small or even invisible computers.
- Ubiquitous Computing deals with an extremely large number of non-traditional computing devices. Since every object potentially could be connected, this

creates a number of network nodes and edges previously unthinkable.

- Ubiquitous Computing also deals with gathering information about the environment through sensors. The goal is to create context awareness, allowing intelligent devices to make decentralized decisions.
- Since mobility is an integral part of this paradigm Ubiquitous Computing requires the ability for ad-hoc network detection and connection.
- Ubiquitous Computing deals with often invisible interfaces to smart networked objects, therefore requiring new forms of human-machine interactions.

Ubiquitous networks will allow the connection to any object at any given point in time from anywhere and by anyone through anything. However, as stated in [4], the dimensions of information exchange and communication capabilities will not be limited solely to users but will also include any and eventually all inanimate objects. This ubiquitous networking capability coupled with the interconnection of intelligent objects provides the foundation for the internet of things [5].

### *B. Framework for Identifying Value-Creating Applications*

Since ubiquitous computing was found to provide significant opportunities particularly within service innovation, the presented scenario is based upon the premise of providing anxiety-relieving monitoring and risk services by being always connected, always aware and demonstrating pro-activity with the customer.

Our research is based on a framework by [6], that focuses on the "challenges identifying value-creating applications both ex ante and ex post". As is shown in Fig. 1, by overcoming network, constraint, implementation and valuation challenges, the sources of value might lead to the tangible benefits of each player.

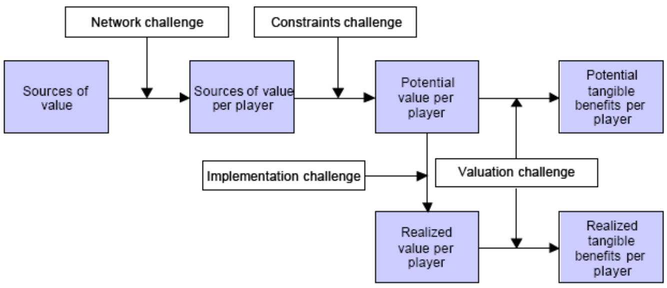


Figure 1. Framework to Identify Value-Creating Applications in Networked Applications (cf. [6])

The scenario presented in this paper will attempt to identify and address some of the challenges using the above-mentioned framework as well as determine intangible and tangible benefits. Furthermore, specific cost drivers will be identified based on the technical requirements of the solution to provide an overview of which elements must be taken into consideration to essentially realize the innovative ubiquitous computing applications.

## III. Wireless Monitoring Architecture for Damage Prevention

Insurance companies have been confronted with increasing claim payments in the water pipe damage insurance segment. Although claim ratios are still acceptable the trend is pointing towards increasing issues with burst water pipes and damages caused through flooding. The damages are usually caused through leaks in water pipes, damaged dishwasher and laundry drains, defective valves as well as improperly shut valves [7]. The damages increased by 10.1% in 2006 and have caused claim payments of over 1.94 million Euros in 2007 alone [8]. This implies a claims rate of 67.1 percent in 2007 [8].

Insurance companies need accurate information regarding the cause of damage. It has become increasingly difficult to assess the causes challenging claims assessors and insurance appraisers to determine potentially fraudulent activities as well as providing risk prevention measures to its customers. Additionally, faster notification of damages including a higher degree of detail of damage assessment information is required from insurance companies to minimize the extent of the damages through improved responsiveness. Since water damages are usually found in areas that are "invisible" or infrequently visited there are very few options that are available to insurance companies to reduce this risk. Plumbers and other maintenance workers would be too costly; demanding the customer to check every area of the household for possible humidity increase would be too unrealistic.

Ubiquitous computing allows a feasible and viable solution. ZigBee offers low-cost, low-power and reliable network capabilities. The combination with sensor technologies creates a low-cost and reliable monitoring system that can be easily deployed in any environment and is particularly designed for the home automation market. When combined with a GPRS module for data transmission, insurance companies could be able to offer simple, cost-effective, risk preventing monitoring services. Fig. 2 illustrates the proposed technical architecture of the solution, which focuses on water and humidity sensor networks within apartments, buildings or facilities.

The primary goal of the solution from the perspective of the insurance company is to provide a cost effective risk prevention method that reduces the trend of increasing water-related damages. There are two distinct ZigBee based network nodes. The first offers simple water and humidity sensing capabilities, while the second node type is integrated with an automatic shut-off valve mechanism. The first simple sensor node can be placed throughout the house, preferably in areas that are less frequently occupied or visited such as basements, attics, utility rooms, and under refrigerators. The second sensor node is comprised of a sensor and valve component that automatically closes or opens the valve depending on pre-determined sensing parameters such as sudden increases in humidity or changes in water pressure. They should be installed next to dishwashers, washing machines, main water valves, garages and other valve locations. The nodes are battery operated and have a lifespan of over 10 years due to the low-power requirements of the ZigBee protocol.

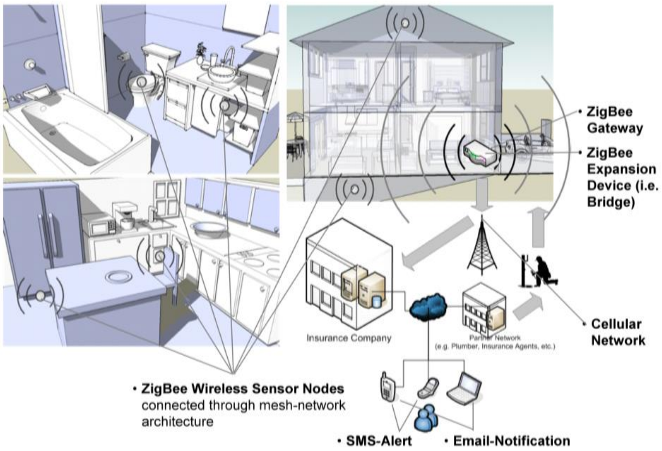


Figure 2. Wireless Mesh Monitoring Solution Architecture

The final component is a base station, which includes a ZigBee coordinator device, a GPRS module for communication as well as software for communication and sensor management. The coordinator device can be either a ZigBee gateway or bridge. A ZigBee gateway is "intended to provide an interface between ZigBee and IP devices" while ZigBee bridges extend ZigBee networks over an IP based network [9]. Bridges are low cost and simple to implement and would be pre-programmed with the insurance company's IP address. Gateways are designed to convert the sensor data into a variety of different formats that are necessary for industrial, commercial and residential systems. Depending on the requirements of the individual insurance company, both ZigBee bridge and gateway architectures are viable solutions. Since not all households are equipped with broadband connectivity, the IP connection is established through the GSM/GPRS cellular network and would only be used when particular threshold levels have been reached thereby minimizing the monthly data transmission volumes.

The coordinator device would receive signals from all nodes on a continuous basis and determine whether threshold levels have been exceeded. The gateway would analyze sudden but subtle changes in humidity, sudden increases in humidity, and detection of water particles. If any of these events occur the gateway would initiate connection to the insurance company system and forward the alert message. The message would include the sensor node or nodes that sent the signal and the unique identifier of the location and policyholder. Simultaneously an alert SMS is sent to the owner to warn about possible water damages. The claims process would be initiated whereby a customer service representative would contact the owner to verify the occurrence of water damage.

The insurance system provides additional services such as connecting and managing a partner network, which can include qualified plumbers, insurance agents, as well as repair and restoration companies. In case of a valid water damage claim or if the home/facility owner is not available during an alert message, the system would automatically initiate the claims process, pre-fill all required information including sensor type information and assign the geographically closest and most cost-effective plumber or agent from the partner network for close inspection and assessment of damages. A viable variant are „pre-defined" sensors, allowing customers to place specific sensors in pre-defined locations throughout the apartment, building or facility allowing insurance companies and potentially plumbers to spend less time searching for the origin of the damage.

## IV. Decision Support Framework

### A. *Identifying and Addressing Challenges*

Network challenges exist due to the required external partner network of plumbers, agents, repair and restoration organizations. Although a short-term solution enabling communication and organization with partners through mobile phones is feasible, at some point in the future it will become important to enable the exchange of information between systems to ensure real-time availability of partners (i.e. location tracking), automatic billing and payment as well as monitoring of repair/restoration status.

Due to the simplicity of the system no particular legal or social constraints can be identified. Privacy concerns regarding monitoring services must be approved by the insurance policyholder and therefore do not constitute any legal constraints. However, technical constraints exist whereby the first relates to the system integration challenges, which were mentioned in the previous scenario and traditionally cause challenges in ubiquitous computing applications [6]. The second technical constraint would be the reliability of the sensor modules ensuring that no incorrect data is forwarded to the base station. Incorrect or manipulated data could result in an incorrect alert message.

Implementation challenges exist with available manufacturers and integrators of ZigBee based sensor networks within Europe. A more threatening implementation challenge is the occurrence of false positives. False positives are characterized by humidity changes and water particle detection that trigger an alert but are not related to water damage or are a result of events that are not covered by the insurance policy. The causes of such false positives need to be tested, verified and subsequently eliminated during an initial pilot phase and should be taken into consideration as an additional provision cost. The biggest challenge however is assessing where the standard locations for possible water damage incidents occur. This is important to ensure that firstly the high-risk areas are being protected and secondly that customers are able to place the sensors correctly by themselves throughout the apartment or building or at least with minimal guidance from customer service. To maximize the benefits of such a solution, the system should be designed in such a way that the customer is able to install the nodes and base station without requiring additional assistance.

The main challenge in determining the value of the system is comparing the risk reduction of water damages before and after the installation. Since the possibility exists to reduce the emotional burden and the additional stress associated with the "clean up" phase of a water-damaged incident, it will be difficult to determine how customer loyalty will be translated into additional revenue generating opportunities for the insurance company. And finally, the ZigBee network is extremely scalable offering the long-term potential of including additional wireless sensor nodes. These can be used to detect fire, smoke, gas, or the open and closing of doors and windows (burglary alarm). Therefore, the question remains how this scalability effect should be taken into consideration when evaluating the current application.

### *B. Business Models, Stakeholder Benefits and Cost Drivers*

The stakeholders of the system include the insurance company, insurance agents, insurance appraisers, customer service representatives, insurance customers, plumbers and other repair and restoration companies. Insurance customers that could benefit from such an application include, for example, apartment owners, vacation or other secondary home owners, special housing (e.g., tourism, elderly, disabled, etc.), building owners, facility management companies, and any other type of owner of insured buildings.

Two potential business models could exist for such a solution, which would require a service provider as an additional stakeholder. The first business model relates to the insurance company offering the hardware directly to the customer whereby subsidizing the cost of the hardware over the lifespan of the insurance contract. The subsidy would be based on the potential reduction of claim-related expenses due to lower risk probabilities. The second model refers to a concierge type business model [10], which would require an insurance company to partner with a solutions provider, such as a telecommunication or security company. The service provider would sell the hardware solution directly to the customer offering the insurance product as a complementary service, whereby a rebate could be offered to the customer through a subsidy from the insurance company. The information would nonetheless be accessible by the insurance company through the service provider. Both business models have the potential for insurance companies to reposition themselves from a strict financial restitution oriented to an innovative problem-solving oriented company.

The *key benefits for the insurance company* are:

- Reduction in claim related expenses
- Reduction in overall risk and "moral hazard"[1] with little required effort from customer
- Improved customer loyalty through pro-activity and "problem solver" positioning
- Improved brand awareness through product differentiation

The *key benefits for the insurance customer* are:

- Premium payment reductions
- Real-time monitoring of "hidden" areas increasing sense of security
- Faster response to critical events minimizing damages of valuable items
- Simple installation requiring no technical skills
- Unobtrusive and hidden system

The *key benefit for both, the insurance company and the insurance customer*, is the possibility for future innovative products and services through scalability and flexibility of solution (e.g., home-away services, micro-services, security services).

The primary tangible benefit for insurance companies is the reduction in claim related expenses. The reduction of expenses can be found in lower restitution of damaged items; repair costs for walls, floors, plumbing and ceilings; restoration fees; and administrative overhead. The faster transfer of control from customer to insurer due to the automatic claim notification allows for costs to be managed more effectively and the extent of the damages maintained. When taking network effects into consideration, the overall risk of extensive water damages could be reduced. This enables insurance companies to forward the risk savings onto the customer in the form of lower premiums or improved quality of service. Offering customers the low-cost monitoring hardware creating an incentive by lowering premium payments could minimize the moral hazard problem.

An insurance company could differentiate itself with such a solution by positioning itself from a discounter to a problem solver. It may create a lock-in effect with customers due to the simple installation, the unobtrusiveness of the sensor nodes and the increased quality of service when comparing to competitors. Due to the availability of the risk-related information at the moment of occurrence, insurance companies will be able to respond faster thereby verifying the customer's "moment of truth" improving customer satisfaction as well as increasing brand value. Not only can the insurance company respond faster to events, the second sensor type with the integrated shut-off valve function could eliminate any additional damages by automatically closing the affected valves. This plays a particularly important role in situations when nobody is available to perform this task.

### *C. Key Drivers*

Based on the identified benefits described above, the cost of the system needs to be justified. Due to the use of ZigBee based sensor nodes, the costs of deployment can be kept low. Fig. 3 provides a list of key drivers according to the categories of risk reducing factors, market potential influence factors, cost drivers, and other factors required for evaluating the scenario, for instance with methods such as net present value (NPV) and internal rate of return (IRR) calculations.

[1] Moral hazard refers to a condition whereby the customer waives the responsibility for risk or damage prevention measures or even instigates the damage after the closing of an insurance policy. This is a common phenomenon in the insurance business, which cannot be eliminated but can be minimized [11].

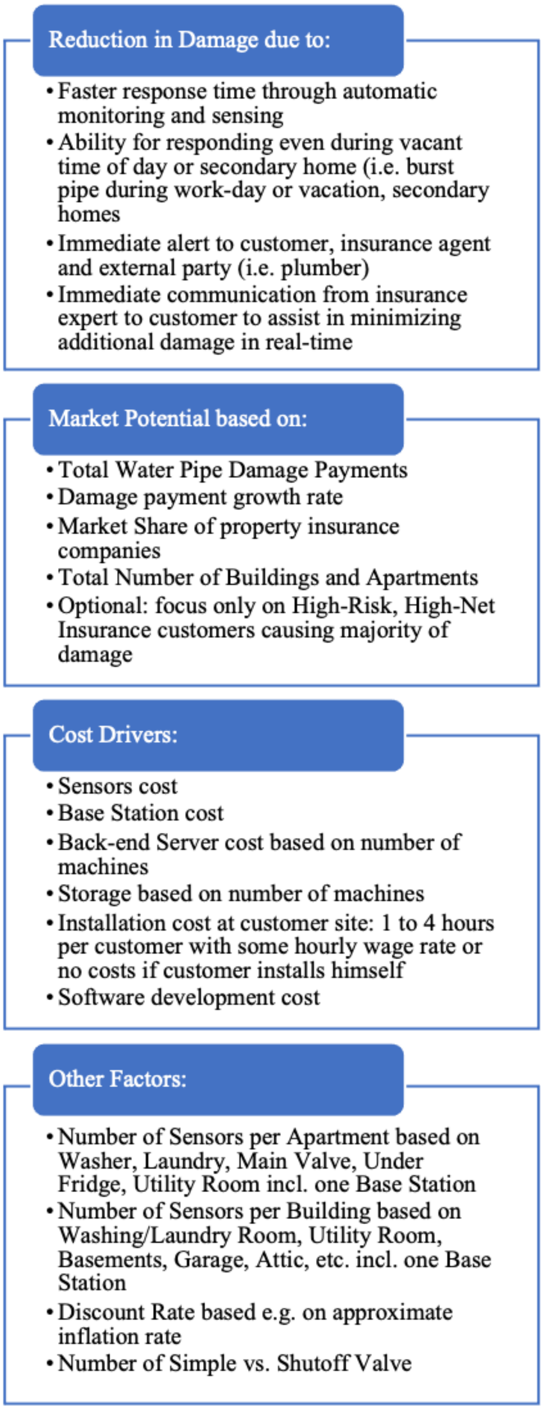


Figure 3. Overview on Cost/Benefit Categories and Key Drivers

### D. *Decision Support using Scenario Technique*

Scenario technique [12, 13] is a qualitative and long-term predictive analysis tool dealing with the development and analysis of possible future scenarios. It maps future developments of environmental situations (scenarios) in different basic conditions as alternative pictures of the future. Using scenario technique requires initially the identification of determining factors. Subsequently, only a limited number of scenarios are considered (e.g., extreme scenarios such as positive extreme scenario, negative extreme scenario) or trend scenarios or especially relevant or application-typical scenarios.

Scenario technique includes analysis of tasks and problems (determining and describing the analysis object and relevant, influencing factors), analysis of influence (factors), trend projection and determination of scenarios (various possibilities for development, possible values of factors, development of scenarios by combining factor values, generating bundles of alternatives), assessment and interpretation.

The decision support framework may include results of various distinct scenarios: e.g., pessimistic and optimistic variables allow for differences in costs and relative values of tangible benefits, whereas aggressive and conservative scenarios allow for difference in customer-related drivers, such as number of sensors per site. Such partitioning generates four possible scenarios: pessimistic and conservative, pessimistic and aggressive, optimistic and conservative.

The process of scenario development essentially includes following steps (cf. [12]):

- Specify the major issue you are facing
- Define the scope of analysis
- Identify the major stakeholders
- Identify basic trends
- Identify key uncertainties and isolate key drivers (external forces)
- Construct about three initial scenario themes (in terms of short stories), each highlighting a different key driver (e.g., pessimistic and conservative, pessimistic and aggressive, optimistic and conservative)
- Check for consistency and plausibility
- Identify research needs
- Develop quantitative models (determine the implications of each scenario for the issue being considered)
- Develop learning scenarios (consider possible strategies to respond to each implication)

Although the framework presented in the sections above is not yet ready to use for final decisions on a company level, it spans most steps necessary for evolving towards decision scenarios. The next steps to be taken are further research endeavors that allow expressing drivers in terms of tangible, quantitative figures.

The major challenge for successful innovations in such a fast moving market is to forecast figures as precise as possible considering all major drivers, in particular the most uncertain ones. In its current state, our framework provides both researchers as well as operators in insurance sector with valuable information what to consider for calculations and prognoses allowing developing adequate quantitative models and learning scenarios, which can finally lead to decision scenarios.

The framework is not only intended for risk management, leading to the decision whether or not to invest in this innovation (feasibility, efficiency), but is designed for monitoring throughout the application's live operation. From the point of view of the insurer the framework may serve various purposes with respect to risk management, pricing, and agile management. The use of sensors and ZigBee enables, for instance, to generate just-in-time damage statistics, which allows insurers to react immediately, serving as a base for strategic decisions. Furthermore, changing environments and trends can be rather easily mapped in the quantitative elaboration of the framework. This shall improve an insurer's risk management performance. Particularly in the insurance sector, pricing is frequently adapted to changing environments, external risk factors, customer behavior, etc. The framework facilitates the continuously necessary recalculation of insurance premiums.

## V. Conclusions and Future Work

The insurance industry entails an important position in the modern economy. It was discovered that insurance companies are facing a difficult time period due to an increased competition from external companies, the proliferation of internet connectivity forcing companies to increasingly compete on price due to sensitivity of the customers as well as increasing elements of risk particularly due to theft and water related damages.

Ubiquitous computing enables the convergence between the physical and the digital world. It allows for the identification, monitoring and tracking of physical objects, which constitutes for potential innovation opportunities for the insurance industry.

This paper introduced a novel ubiquitous computing application that could provide for a solution to the immediate threats confronting insurance companies in Austria. The low-cost monitoring and tracking solutions could enable insurers to reduce their exposure to risk and limit the impact of moral hazard. Customers would benefit by a perceived increased sense of security and a potential reduction in premium prices due to a network effect of overall reduced risk. Besides the immediate benefits of damage prevention or at least the early detection of damages, such an application could change the relationship between insurer and customer, shifting the role of the insurer from traditional paymaster towards a trust-worthy problem-solver or helper.

The scenario described has the potential of being implemented within the near future. Experience has demonstrated that the most effective method for determining the full potential of a ubiquitous computing solution is through the development of a pilot project. Pilot projects can help understand how ubiquitous computing solutions may impact the revenue or cost side of the business and allow for the foundation of business case calculations. Furthermore, pilot projects can assist in determining how potential users perceive the benefits of the system and whether or not they provide any resistance due to possible privacy implications.

Still, before entering into a pilot phase, a precise feasibility study is required, calculating and analyzing the costs of the proposed implementation in terms of efficiency. In addition to its primary aim of supporting insurers in their flexibility and responsiveness on the market, the framework of indicators, parameters and influencing factors, presented in this paper could also provide a sound basis for the cost estimation of such a pilot project. Besides evaluating the applicability and impact of the implementation of this innovative scenario in damage prevention, the pilot project also aims at evaluating the framework in its role for cost monitoring in live operation. Via sensors and ZigBee, damage statistics can be computed just in time. This allows insurance companies to react immediately and adapt their calculations, pricings, or implementations accordingly.

Our next step in research endeavors will, thus, address the issue of adequate cost forecasts, including net present value (NPV) and internal rate of return (IRR) calculations based on the introduced framework and on expert knowhow.

## References


[1] N. Bjørn-Andersen and S. Elliot, "E-Business Perceptions Versus Reality: A Longitudinal Analysis of Corporate Websites," presented at the 6th International Conference, EC-Web 2005, Copenhagen, Denmark, 2005.

[2] H. W. Chesbrough, *Open Business models: How to thrive in the new innovation landscape*. Boston, MA: Harvard Business Press, 2006.

[3] The International Conference and Research Center for Computer Science, in *Dagstuhl Seminar on Ubiquitous Computing*, Dagstuhl, Germany, 2001. Available: http://www.vs.inf.ethz.ch/events/dag2001/

[4] T. Murakami, "Ubiquitous networking: business opportunities and strategic issues," *Nomura Research Institute Papers*, vol. No. 79, pp. 1-12, 2004.

[5] A. Ferscha, *et al.*, "Peer-it: Stick-on solutions for networks of things," *Pervasive and Mobile Computing Journal*, vol. 4, pp. 448-479, 2008.

[6] E. Fleisch and C. Tellkamp, "The Challenge of identifying value-creating ubiquitous computing applications," presented at the 5th International Conference on Ubiquitous Computing (UbiComp 2003), Seattle, Washington, 2003.

[7] Allianz. (2009, 10 May). *Rohrbruch - häufigste Schadensursache*. Available: https://kundenservice.allianz.de/ratgeber/schaden_verhueten/rohrbruch_haeufigste_schadenursache/index.html

[8] Versicherungsverband Österreich, "Jahresbericht 2007," 2007. Available: http://www.vvo.at/jahresbericht-zahlen-und-daten/189.html

[9] P. Kinney, "Gateways: beyond the sensor network," in *Sensors Expo & Conference Presentations*, 2005. Available: http://www.zigbee.org/zigbee/en/events/documents/SensorsExpo/7-Sensors-Expo-kinney.pdf

[10] T. Nagumo, "Innovative business models in the era of ubiquitous networks," *Nomura Research Institute Papers*, vol. 49, pp. 1-11, 2002.

[11] J.-M. G. v. d. Schulenburg, *Versicherungsökonomie: Ein Leitfaden für Studium und Praxis*. Karlsruhe, Germany, 2005.

[12] P. Schoemaker, J.H., "Scenario planning: a tool for strategic thinking," *Sloan Management Review*, vol. 36, pp. 25-40, 1995.

[13] G. Wrigth, G. Cairns, and P. Goodwin, "Teaching scenario planning: lessons from practice in academe and business," *European Journal of Operational Research*, vol. 194, pp. 323-335, 2009.