

# Introduction to the Business Processes with Ambient Media - Challenges for Ubiquitous and Pervasive Systems

Artur Lugmayr

EMMi Lab., Department of Business Information Management and Logistics,  
Tampere Univ. of Technology (TUT)  
P.O. Box 541, Korkeakoulunkatu 8, FI-33101 Tampere, Finland  
lartur@acm.org

**Abstract.** Ambient media (aka ubiquitous media) are around us since quite a while. First products and services are emerging in our daily lives. The connection between the physical environment and the digital overlay through smart sensor networks became reality. However, many believe that the application of ubiquitous technology in real commercial solutions is still far out in the future. Within the scope of this paper, we introduce the reader into the business opportunities of ambient media and give a technology roadmap how this new technology might be developing during the next years. The paper shows current shortcomings, technology trends, and existing business solutions and attempts to forecast it's potentials in the next decade. The reader is introduced into issues of supply chain management, application domains, ubiquitous technology in (e)commerce, standards, and business models based on ambient media. This paper shows the perspective from a telecom operator, content creator, consumer, device manufacturer, consumer, and domain specific value-chain participant. It shall act as starting point for further investigation of the business of ambient media.

**Keywords:** Ubiquitous computation, pervasive computation, ambient media, ambient intelligence, agent based computation, RFID.

## 1 Introduction

The revolution of ambient media took place silently during recent years. Much ambient technology emerged in consumer homes or into supply chains without actively noticing the underlying technology. There exist many examples, such as location based services on mobile phones, RFID technologies for supply chain management, and smart sensor networks in cars. Currently there is poor research work on the business aspects of ambient media, due to the fragmented nature of applications, services, technologies, and consumers. However, the main question of this publication is: *How can ambient media improve businesses?*

To understand the business of ubiquitous media, we have to understand the different impact factors and parameters before analyzing existing literature. For the scope

of this article, business developments around ambient media have been categorized according the following criteria:

1. global and macroeconomic trends;
2. technological enabler and base technologies;
3. integration of physical world and digital overlay; and
4. value-creation through additional services and application;

As the topic is rather wide, and many more than the covered aspects could be discussed, the following aspects have been emphasized:

- increased data quality, accuracy, and granularity;
- improved and optimized production processes;
- integration and harmonization of information management;
- characteristics of ambient media and the key-technologies;
- integration of value-chain and automation of the supply chain;
- etc.

As the basis of investigation and discussions, the article considers the following services and application for comparisons and examples of ambient media examples:

- Nokia's Ovi Maps and Google Maps as examples for navigation;
- Stress monitoring systems developed by Firstbeat Technologies (see [23]);
- Competition entries for the Nokia Ubimedia Awards organized by Mind-Trek Ry (see see [1]);
- Results from the SAME workshop series as organized by the Ambient Media Association (AMEA) (see [1]).

Currently there is a quite wide set of global and macroeconomic trends. These trends directly impact on business in general, however, as well as on the development of ambient media. In the following the most significant trends have are enumerated:

- Aging population vs. population growth
- Confusion on financial markets
- Global warming and climate change
- Regulation policies and government policy
- Globalization and internationalization
- Sustainable energies
- Consumer and society behavior
- Unions and other interest groups

From the technological side, many technical enablers led to the development of ambient media as they exist today. The most significant ones are:

There exist several technical enablers:

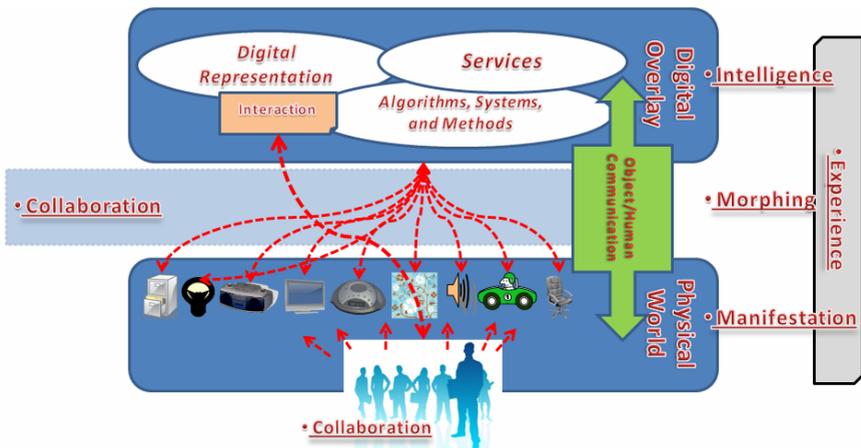
- RFID tags
- Sensor and actuator technologies

- Middleware and thin client technology
- Miniaturization of electronics

This publication is structured as follows: section 2 introduces ambient media as concept, and reviews its most significant related works; section 3 presents how the physical world and the digital overlay can be integrated, and what the major technical components are; section 4 very briefly pinpoints to the major technological enablers and basic technologies in relation to supply chain and value chain; section 5 provides a roadmap and discusses the results.

## 2 Very Brief Introduction to Ambient Media

Ubiquitous computation and pervasive computation had their starting points during the 90s, and their foundations have been laid in various publications (e.g. [24] [25]). Ubiquitous computation laid the foundation of technology leading to ambient technology. However, the idea rapidly evolved with the introduction of ambient intelligence, which improves the ideas by a more holarchistic viewpoint towards ubiquitous computation. With the introduction of ambient intelligence as European Framework around the year 2003, the foundation for a new concept has been laid [9] [8]. This new technology is the basis for investigation within this work as well as it is for ambient media technology. But this work introduces the concept of building a media environment on top of ambient technologies. However, any new introduced technology has implications on the form how content is presented. As e.g. film cameras introduced the medium motion pictures, also ambient technology introduces the medium ambient media. Many times ambient media are solely discussed as possibility



**Fig. 1.** Depicting the idea of ambient media as digital overlay over the physical world. The principles of ambient media (*manifestation, morphing, intelligence, experience, and collaboration*) are included (see e.g. [13]).

for advertising embedded throughout the natural environment. However, ambient media go much further, and embed a media environment into the natural human environment. This issue has especially been discussed in [13], [15], and [16].

Ambient media are characterized through the following principles [13]:

- **Manifestation:** they way how digital objects render through time and space throughout the natural environment (e.g. language output of a GPS based navigation system);
- **Morphing:** how the digital overlay is linked through communication channels to real-world physical objects (e.g. embedded computers sense their environment via data coming from sensor networks);
- **Experience:** knowledge and eventually wisdom based systems based on consumer experience (e.g. agent based systems or personalization systems turning data to knowledge);
- **Collaboration:** collaboration rather than interaction and interoperability are the key in ambient systems. Ambient system technology collaborates between themselves or the users collaborates with the system (e.g. language based input or automated interoperable systems);
- **Intelligence:** methods and algorithms to smartly interpret data and the environment (e.g. systems aggregate content rather than push/pull schemes).

### 3 Integration of Physical World and Digital Overlay (Morphing)

One principle of ambient media is the principle of morphing, where the physical world is connected to a digital overlay. A ubiquitous system ‘sees’ its environment through sensor networks, and reacts by utilizing actuators in the physical world. Especially in *Business Information Systems (BIS)*, we can identify several challenges which are relevant for realizing ubiquitous systems:

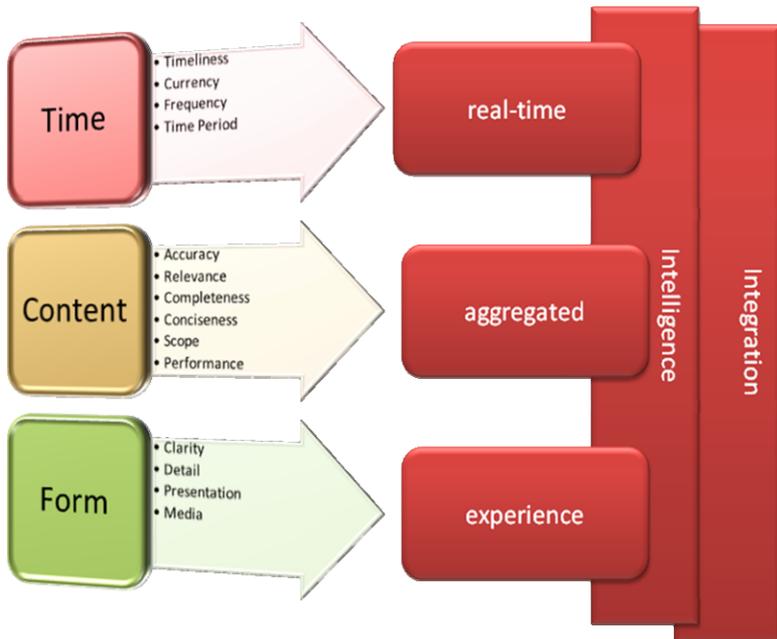
- information quality;
- integration of information systems;
- costs for realization; and
- information reporting.

Information quality addresses the need of precise, timely, and valuable information obtained through information systems. The key-attributes of such systems are presented in Fig. 2. As stated in [19], the attributes of information quality can be put to the following categories:

- *Time-attributes:* attributes dealing with when, freshness, how often, and for which time-span data is available;
- *Content-attributes:* attributes dealing with information error-freeness, relevancies in specific situations, sufficiency, and the message to be transmitted;
- *Form-attributes:* attributes dealing with information presentation, interaction, and the way how it is presented to the consumer;

In the case of ambient media systems, pervasive technology has several advantages in comparison to other technologies:

- increased timeliness of high quality information in ‘real-time’;
- automated aggregation of information rather than push/pull schemes;
- integration of information management systems and processes; and
- application of intelligent algorithms for information processing;
- information consumer experience orientation for presentation and interaction.



**Fig. 2.** Attributes of information quality in general (from [19]), and their application in ambient media systems through the attributes *real-time*, *complete*, and *interpreted*

### 3.1 Increased Timeliness of High Quality Information in ‘Real-Time’ (Real-Time)

In [6] a discussion about two essential factors concerning the increased timeliness of high quality information have been discussed: 1) advantages of applying ambient technologies for data gathering in comparison to manual based information gathering; and 2) affects of data quality in business environments that are based on ambient technologies.

Especially the mapping between the physical world and the digital overlay allows closing the tradeoff between the visions of the ‘real-time’ enterprise and the ‘low data

quality' enterprise. In a real-time company, ambient intelligent technology collects highly accurate information with a high frequency to be considered for further evaluation. However, currently the costs for realizing the 'real-time' enterprise are currently simply too high. Low quality data, gathered at lower frequencies is given preference, due to lower costs. One typical example is e.g. retail, where nowadays yearly inventories are preferred, rather than investments in improving the tracking of sales goods between retail shelves, storage space, and product distributors via RFID tags. For further reading, please refer to [6].

### 3.2 Automated Aggregation Information Rather Than Push/Pull Schemes (Aggregation)

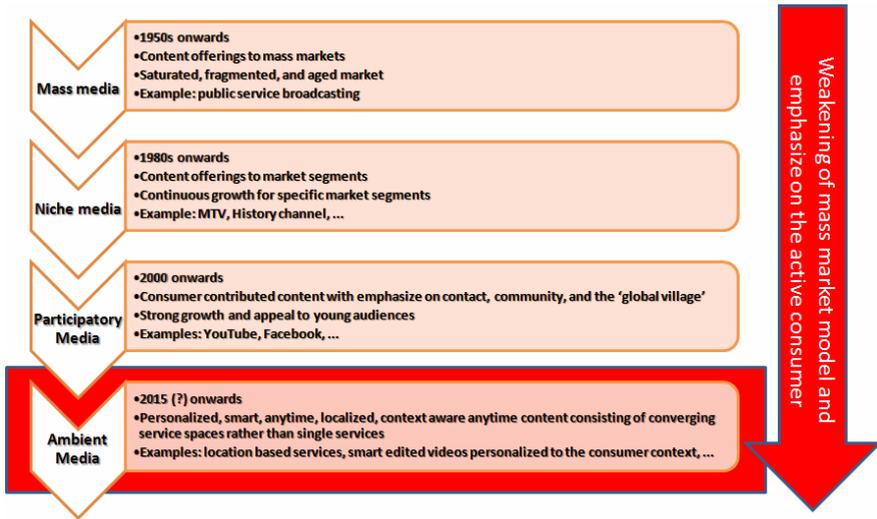
Ambient media shift the responsibility of compiling content on system level. Nowadays people either pull the content from the web by explicitly searching for it via search engines – or they get the content pushed to their homes, without direct possibility to change the content, as e.g. in broadcasting. However, the future is aggregation, where the system compiles content in behalf of the consumer – contextualized, personalized, and individualized.

One excellent example is the *Portable Personality (P2)* software, which collects metadata from various sources. An engine mines the metadata to usage context on any device and provides personalized content from any source [14]. Other more prominent examples are Google news or location based services as currently provided e.g. by Nokia Maps and Google's mobile services.

One of the key issues is how data can be integrated into *Business Information Systems (BIS)*. Currently many client based solution for ambient media start to emerge on markets (e.g. location based services). However, the process of integration of data of ubiquitous systems still requires much development. Examples for a professional integration of data are e.g. integration of location information to film material during movie production. The challenge is the automation of the process.

Viewing the automation and smart integration of data from a media viewpoint, let's refer to Figure 3. Today's media landscape is dominated by participatory media (e.g. social media). However, the content model in the past evolved from content offerings to a mass market, niche media (e.g. themed TV channels), towards participatory media, where the consumer is the content creator. In the future, the media environment will be evolving towards a smart environment, where existing journalistic practices are shifting towards personalized context aware service spaces rather than single services. The key to enable smart media environments and integrated service spaces is context information.

Depicting the idea of ambient media as digital overlay over the physical world. The principles of ambient media (*manifestation, morphing, intelligence, experience, and collaboration*) are included (see e.g. [13]).



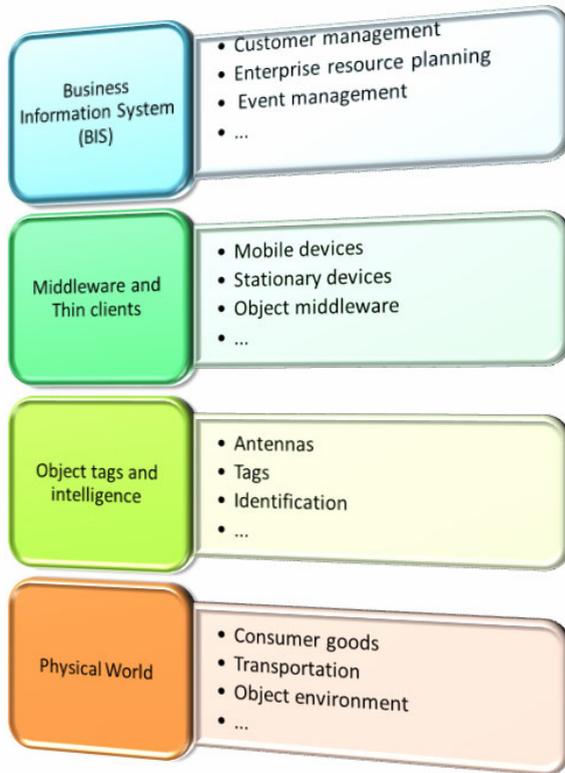
**Fig. 3.** Evolution of the content model – from mass media (to mass audiences), niche media (themed to market segments), participatory media (consumer contributed content), towards ambient media (smart media). Extended by ambient media and further descriptions from [12].

### 3.3 Integration of Information Management Systems and Processes (Integration)

The integration of information management systems and processes spans partners from the whole value chain. They require harmonizing their ways of exchanging either tangible or intangible goods. This is especially important in supply chain management. Supply chain management deals with “controls the flow of products and services from suppliers right through to the end consumer” [22]. Efficient and productive supply chain management is enabled through the integration of information management systems and processes. This can only happen through the development of common agreements how information exchange between business partners is taking place between information systems.

Considerable efforts have been done on the field of electronic commerce, which let as series of standards emerge that cover 1) identification; 2) tracking; 3) management; and 4) protection of either physical or digital goods. A compilation of standards normally utilized in electronic commerce has been discussed in [20]. The publication discusses a wide set of standards typically used in supply chain management such as e.g. bar codes, RFID tags, EPCglobal, and EAN.UCC. These standards are used to uniquely identify products and their application for supply chain management is common in today’s world of eCommerce. However, the publication also pinpoints to other – more advanced – standards for the automation of the supply chain, such as ebXML. ebXML has been designed by the *Organization for the Advancement of Structured Information Standards (OASIS)* on the basis of XML. The standard enables among other possibilities the automation of *messaging, business processes, and exchange of trading partner profiles*.

Where the upper standards mostly focus on physical goods, the market for intangible digital goods is rapidly increasing. The B2B exchange of digital media is on the raise, and the development of common formats for the exchange of information is required. This trend is very visible e.g. in the film & TV industry, where standards such as the *Material eXchange Format (MXF)* are published [18]. MXF enables the exchange of content across media production houses via the Internet rather than on physical carriers such as tapes. This enables the automation and integration of the supply chain from production house to the final distributor and further to the consumer.



**Fig. 4.** Integration of information systems from *Business Information Systems (BIS)* down to objects in the physical world (extended from [7])

It is obvious, that with a rapid increase of ambient media technology, the automation of the supply chain is taking place. Currently there is still a trade-off between costs and benefits, but with the decline of costs of miniaturized technologies the gap will get closer. Ambient media allow a seamless integration of the value chain and speeding up the business processes, especially with the advent of more and more digital goods. However, the integration of information system happens vertically, from *Business Information System (BIS)* down to the physical world object level. This

implies a harmonization of all the levels to enable full integration of several platforms (see Fig. 4). The vertical integration of the value chain and the need for harmonization has been discussed in [7]. One major issue is the integration of middleware from end-to-end. This issue has been discussed e.g. within the SAME workshop series in [21].

### **3.4 Application of Intelligent Algorithm for Information Processing (Intelligence)**

Intelligent methods and algorithms for information processing are predominant in any ambient media system. One of the key-technology is agent based computation. Agent based computation currently provides one of the main solutions, where software reacts autonomously on external stimuli. One practical example is e.g. the 3APL-M platform, which provides the core technology for deploying smart software on mobile devices. Agents on mobile phones are e.g. capable of contextualizing sensory input in behalf of the consumer [11][10].

### **3.5 Consumer Experience Orientation for Information Presentation and Interaction (Experience)**

The research field of consumer experience is hyping in today's IT services. However, the idea behind consumer experience goes far beyond the current though of simply improving user-interfaces and providing cool hardware designs. The idea of experience in ambient media is that experience means knowledge. Thus experience relate to how humans enjoy media and how humans "act or process directly perceiving events or reality" [17]. Thus, neither the product (e.g. hardware), nor the services attached to the hardware, and nor content is king. The experience as such, consisting of a service space as agglomeration of devices, services, and content is king. Interoperability is one of the technical key-factors to create such an experience.

There are quite a few examples that underlay this direction. One is 'The Cloud', where services are embedded into the Web and the consumer can access a full service cloud online. In ambient media, the vertical and horizontal integration of household equipment will lead to an integrated space, where many devices collaborate. The human becomes a collaborator rather than a user of the system.

## **4 Value Creation through New Applications and Services**

Within the scope of creating value through new applications, content, and services, we have to distinguish between consumer applications, and the application of ambient technology throughout the supply chain. Currently much research is centered on consumer applications, as they are easier to introduce rather than to change existing business processes. Within the scope of this section, the topic 'value creation' for both business domains is discussed.

The main question concerning value creation through applications is, which challenges business are coping with, when adopting new technologies from the ubiquitous domain. A good starting point has been researched in [5], where four key challenges have been identified based on the theories of [2]:

- **Network challenge:** challenges related to the outbalancing of the value of new technology and cost benefit through the introduction of new technologies throughout the value chain. One example for this challenge is the introduction of RFID tags for retail chains, and who overtakes the costs (either the retailer or the distributor) (see e.g. [5]);
- **Constraints challenges:** challenges related to value chain exterior factors, such as regulations, privacy, or global macro-economic trends. One good example are privacy concerns of location aware services, context aware services, or the data of a smart home;
- **Implementation challenges:** challenges faced due to technological problems, resources, knowledge, and practicability of the planed system;
- **Valuation challenges:** challenges related to the tangible valuation either before investment or after investment.

Several of these challenges directly impact the introduction of new ambient media technology.

To understand the value creation through ambient media services, we have to understand the reason why industrial players should invest into new technologies. To understand the costs and benefits, especially to value the return on investment a suitable taxonomy has been developed in [4] entitled the “benefits ladder”, which is illustrated in Table 1. In the following sections applied ambient media is discussed from the perspective of the Project Ladder focusing on two steps of the ladder: mandatory changes, and automation.

**Table 1.** Benefits Ladder of added value applications for corporations (compiled from [4])

<b>Project Ladder</b>	<b>Meaning</b>
<b>Mandatory changes</b>	Forced changes through competitive pressure, technological necessity, or regulatory/legal necessity
<b>Automation</b>	Cost reduction in production through decreasing production costs or increasing labor productivity
<b>Direct Value-Added</b>	Applications adding direct value to the product through the technical system as such
<b>MIS/DSS Systems</b>	Services improving management level planning, control, and decision making utilizing technology
<b>Infrastructure</b>	Improvements of the productivity of businesses through advanced infrastructure
<b>Inter-organizational Systems</b>	Systems improving cross-organization transactions of any kind
<b>Strategic Systems</b>	Infrastructure to improve competitive advantage, productivity, new ways of managing, and develop new types of businesses (see [3])
<b>Business Transformations</b>	Benefits through systems enabling transformation of business due to lack of success, change of economic environment, survival, weak success in competition, or poor management strategies

One of the most prominent ambient media services are location based services such as e.g. GPS based navigation. Google offered free access to navigation, through their service offering via Google Maps, which provided Google. With the development of a mobile client, also other consumer device manufactures were forced to keep up with the competitive advantage of Google's service to provide free navigation. This is a good example for adding value forced through competitive pressure, as e.g. Nokia had to cope with the competition through free offering of the Nokia Ovi Maps service. However, the later still allows the access to the navigation service offline, thus without Internet access, which makes enhances the competitiveness of Nokia Ovi Map's application.

A good example for automation as infrastructure for improving competitive advantage through new ways of managing and increasing productivity is FirstBeat Technologies [23]. The idea of the developed system is to decrease the stress level and increase productivity and motivation of employees. The developed system allows analyzing stress levels and recovering from stressful situations. The system can be considered as infrastructure increasing work motivation and productivity of employees, thus increasing labor productivity. This system could be also considered as strategic system, and introduce new ways of management by gaining additional productivity through a well-balanced working life.

## 5 Discussion and Roadmap

Nowadays many companies and business don't know the value of ambient media technologies. Slowly they understand the value for their businesses, and why investing in this technology will benefit their revenues. In the following, the levels of the development of ambient media as well as the key-conclusions of this publications are compiled together (see Fig. 5):

**Level 1 (Technical Enabler and Base Technologies):** at the beginning there is always a new technology and technical enablers allowing the possibility for the development of new systems for media. In the case of ambient media, it's mobile technology, emotional computation, smart algorithms, wireless technologies, and smart environments – just to mention a few. Many of these technologies are currently under development or found already their way into consumers' homes.

**Level 2 (Gadgets & Consumer Electronics):** as seen from other domains, this technology is used for gadgets or other household items (e.g. Tamagotchi). Currently location based services are shaping mobile services. We can describe ambient media as silent revolution, happening slowly and in the background, rather than in the foreground. Ambient media are already here, and all-present (e.g. interactive walls in cities).

**Level 3 (Supply Chain Integration):** a more problematic issue is the integration of the total supply chain with interoperable standards and smart data exchange mechanisms. This includes production, as well as the consumer side. Today we see e.g.

tracking systems for trucks as one example. However, the future will show which standards are emerging, and which technologies will be dominating markets.

**Level 4 (Value Chain Integration):** the next step is the value-chain integration, where various business partners are integrating their *Business Information Systems (BIS)* and develop semi-automated process to exchange content, consumer interaction, and services. This step will be the most crucial part.

**Level 5 (Innovation of Models):** as in any S-Curve model, each innovation requires the re-invention of it. Thus at the end of the various levels of development of ambient media, will be the re-innovation of ambient media through new services. However, this is far in the future and new computational models are required.



**Fig. 5.** Levels of development for ambient media systems – from technical enabler towards innovation of the model of ambient media

As conclusion, ambient media services are currently already widely deployed, despite the consumer might not be aware of it. However, what we still have to re-think is, what actually content means, and which impact ambient media will have on other aspects, such as the business supply chain. However, any new technology leads to new innovations, and we are just on the brink of emergence of ambient media.

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