Pervasive Advertising

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Abstract: As pervasive computing technologies leave the labs, they are starting to be used for the purpose of advertising. *Pervasive Advertising* has the potential to affect everyone's life, but it seems that a knowledge gap is preventing us from shaping this development in a meaningful way. In particular, many marketing and advertising professionals have an expert understanding of their trade, but are unaware of recent advances in pervasive computing technologies, the opportunities they offer, and the challenges they pose. Similarly, many pervasive computing researchers and professionals are on top of the recent technological advances, but lack basic marketing and advertising expertise and therefore an understanding of how their technology can influence these fields. This book is intended to close this gap and provide the means to meaningfully shape the future of pervasive advertising.

1 Introduction

The use of pervasive computing technologies for advertising purposes presents huge opportunities and challenges for our future. Pervasive advertising will soon be here whether we like it or not. Its fundamental orientation is being determined now, and the direction we choose will influence the appearance of urban space for years to come. We are at a crossroads, where a decision must be made that will leave us in a better or worse off position. One direction might create a world clogged with pervasive spam, people being spied upon, or subconsciously manipulated to buy things they do not need. However, the choice exists to take the future in a beneficial direction. This is a world in which pervasive computing actually achieves its positive potential. Where any information we may need, contacts to people we know, and inspiring experiences are provided everywhere and at anytime. This is supported by calm and engaging advertising, which respects our pri-

vacy, is honest, and does not manipulate us. These advertisements strike a balance between being calm when we do not need them, and being engaging and inspiring when we want to participate. Our privacy is well protected, and we can inspect our user profiles and change or delete data as we may wish. Some ads persuade us to do things that are in our interests, while unethical persuasion strategies are avoided. The persuasion strategies used are overt, and we have the ability to express our opinion of them. We believe that pervasive advertising has three major challenges that must be addressed; these concern the areas of calm and engaging advertising, privacy, and ethical persuasion.

One major obstacle to addressing these challenges seems to be the considerable number of advertising experts who are largely unaware of pervasive computing technologies and how these will influence and change their business field. They might fear losing revenue if they do not adapt quickly enough to pervasive computing technologies, or might even be tempted to ignore these developments. Furthermore, they know that advertising is an important and necessary activity of any economy, without which most companies would not survive—advertising is simply done well or poorly. On the other hand, there are a considerable number of computer experts who know a lot about pervasive computing but very little about advertising. These individuals may have only experienced advertising as consumers and fear that pervasive advertising will be much more invasive. But they also know that pervasive computing has a lot to offer in terms of automation, interactivity, and ubiquity. As experts from both fields are brought together, synergies will arise that have the potential to greatly improve advertising for all stakeholders.

The chapter aims to narrow the knowledge gap between advertisers and pervasive computing experts by illustrating the core principles of their respective fields. Following an overview of the essential concepts of advertising and pervasive computing, this chapter will propose and address the new technologies, opportunities, and challenges of pervasive advertising. Experts from one or both of these fields are invited to skip the respective introductory sections.

2 Advertising

In this introduction we will provide a brief overview of marketing's core principles. Section 2.4 will then outline current developments with respect to the context of this book.

2.1 Advertising versus Marketing

The terms advertising and marketing are often used synonymously. Marketing is confused with advertising and selling techniques. This is partly due to the fact that the concepts, strategies, and instruments of marketing are often not visible to the typical consumer. Marketing plays an encompassing role and is integrated into a company's entire value creation process.

2.1.1 What Is Marketing?

The American Marketing Association defines marketing as follows:

> Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large.[1]

This definition shows the broad sweep of the marketing discipline. It also describes three important marketing trends. First, marketing serves more than just the purposes of a given business. It also includes the general activities and institutions beyond the scope of traditional organizations. This conceptual extension takes into account that marketing is no longer conducted by businesses alone, but also by agencies, self-organized groups, or even individuals. Moreover, the classical understanding of marketing is no longer restricted to functional aspects. The conceptual scope is much broader, so that marketing also includes non-functional pursuits, for example, activities that are not necessarily associated with a corresponding output. The second important change is the relationship between companies and customers. Especially in the second half of the twentieth century, marketing is no longer limited to the one-way value delivery from companies to customers. Today, buyers and sellers have entered into long-term relationships that focus on exchange rather than one-sided interaction. In particular, with the intensive use of digital communication technologies, customers have become active participants in the company-client relationship. Thus, they can no longer be described as passive value-recipients. The third significant change concerns the recipients of marketing activities since these are no longer restricted to customers per se, but now also include partners and "society at large." Marketing is increasingly viewed as an exchange between companies, customers, and community groups, where all involved parties see each other as equal partners and adapt their expression accordingly.

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[1] AMA (2010). American Marketing Association, URL: www.marketingpower.com [accessed 23/03/2011]

2.1.2 Marketing and Advertising Are Both Goal-oriented

The formulation of clear, long-term oriented objectives is an essential part of marketing and advertising.

Superordinate Goals. The defining of marketing objectives is closely related to the formulation of the company's superordinate goals (Meffert et al. 2007). The first superordinate goal is the business mission that determines the type of services the company will provide. The business mission sets the basic direction for all corporate activities. The second goal is defining the corporate identity, which is most broadly understood as a corporate personality and is manifested in an organization's behavior, communication, and appearance.

Activity Goals. Superordinate objectives help to develop the activity goals related to quality, revenue, and profitability, or to environmental issues. All areas of a company formulate their own objectives in order to achieve these corporate activity goals. In the marketing area these objectives include (Homburg and Krohmer 2009):

- potential-related marketing objectives such as general awareness, image, customer attitudes, or customer satisfaction;
- performance-based marketing objectives such as sales, market share, number of customers, customer loyalty, and market penetration;
- financial objectives such as revenue, marketing costs, profit, or return on sales.

2.1.3 Advertising Is Part of the Marketing Mix

Marketing is based on the marketing mix—a set of marketing instruments that companies use to reach their customers directly. The classical instruments of the marketing mix fall into four areas: product, price, place, and promotion (Kotler and Keller 2008).

Product. Product-related instruments are all activities and procedures that take into account the needs and requirements used to design current and future products. In this sense, the product policy encompasses the maintenance of successful products and the planning and realization of product innovations.

Price. The pricing policy is based on the decision related to the type and extent of compensation that customers pay to use the company's services. Price instruments not only refer to the actual price but also discounts, surcharges, or price timing.

Place. Instruments of distribution consist of all measures designed to sell products and services as well as to logistically organize their distribution. Sales measures directly or indirectly target the purchase process. Distribution measures ensure the availability of the product for the customer.

Promotion. Promotion includes all market communication activities of the company. This includes defining communication objectives and target groups, selecting communication channels, and determining the size of the communication budget. Promotional instruments can be divided into "above-the-line" and "below-the-line." Traditional advertising in newspaper, television, radio, cinema, and outdoor advertising are considered "above-the-line" measures; all other new communication tools are considered "below-the-line." Advertising is by far the most important communication tool in the marketing mix (Burmann 2008).

The technological developments in pervasive computing undoubtedly influence all four instruments of the marketing mix. However, the focus of this book concerns the impact of these developments on advertising as an instrument of marketing communication.

2.2 Advertising

As shown, advertising is one of four areas of the marketing mix. It is defined traditionally as a mass communication process designed to change the recipient's attitudes and behavior (Burmann 2008).

2.2.1 Advertising Definition

Kotler and Keller have formulated a standard definition of advertising that should also define the use of the term in this book:

> Advertising is any paid form of non-personal presentation and promotion of ideas, goods, or services by an identified sponsor. Advertisers include not only business firms but also charitable, nonprofit, and government agencies. (Kotler and Keller 2008)

The general goal of advertising is to transmit information to a specific group of recipients in order to achieve the desired effect. Accordingly, the task of advertising is to systematically plan, design, coordinate, and control all communicational activities of an organization with respect to relevant recipient groups in order to contribute to the marketing objectives.

2.2.2 Advertising Objectives

Advertising objectives have a direct means-end relationship to overall marketing and business objectives. The achievement of advertising objectives therefore contributes to the fulfillment of higher corporate goals (Meffert et al. 2007).

Advertising objectives should be defined by content, scope, time, and target segment. They can be differentiated into cognitive, emotional, and conative goals as the following categorization of advertising objectives shows (Schmid and Lyczek 2006):

Table 1. Advertising Objectives

Cognitive Objectives	If the corresponding need is minor, the essential information about the product or service should be communicated. A need is called minor, whenever the recipient is aware that the need is currently present and that it can be satisfied by available offers. In this case, it is often sufficient to communicate the key features of the product.
Emotional Objectives	Emotional advertising aims to link a product or service with specific emotions that lead to a differentiation from other offerings. Emotions are used primarily in mature markets with technically and functionally interchangeable products (cigarettes, chocolate, etc.).
Conative Objectives	Conative objectives are related to actual consumer action. In this case, advertising aims to stimulate potential buyers to buy, order, use, or take action in any other form.

2.2.3 Involvement

Also important to advertising is the concept of involvement: the strength of the relationship of consumers to an object such as a product or a service. Involvement is critical to advertising because it can significantly impact the purchase decision process. The concept of involvement was introduced into the field of advertising research, and has since become a very important means for explaining consumer behavior. The central assumption is that the processing of information depends heavily on the relevance of the information for the consumer. Thus, involvement is a person's perceived relevance of an object based on inner needs, values, and interests (Zaichkowsky 1985).

In advertising it is important that involvement varies for different types of products. Here, product involvement is the perceived personal relevance of a product that is determined by the individual's needs and values. Generally, we distinguish between high and low involvement purchases. High involvement purchases are of greater importance to the consumer. They are closely related to personality and self-assessment (e.g., car, house) and therefore characterized by relatively high financial, social, or psychological risks. The majority of most purchases, however, are low involvement purchases that are perceived as less important (e.g., food, facial tissues). Here, financial, social, or psychological risks are low, so that consumers often do not search extensively for information and rarely

look for product alternatives. Low involvement will therefore generally lead to a restricted decision making process. The standard approach in advertising is the following: for low-involvement products, advertising generally contains a small amount of information and is repeated frequently; for high-involvement products, advertising contains more information and will be repeated less often (Kuss and Tomczak 2007). The individual's involvement plays an important role in the categorization of buying behavior.

2.2.4 Categories of Buying Behavior

For a comprehensive understanding of advertising, it is important to analyze different decision making processes and their relationship to involvement. Generally, distinctions are made between the following four basic types of purchase decisions (Kroeber-Riel and Weinberg 2003):

Extensive decisions are also called real purchasing decisions. The decision to purchase is based on a high cognitive and emotional involvement. Products that trigger extensive choices are usually expensive durable goods, which have a long life. These cause the buyer to check many alternatives before buying. Information demand is particularly high, as buyers usually only have limited experience with the purchase of similar products. The high cost and long life of the product also raises the stakes of a poor purchase.

Habitualized purchase decisions are those purchases for which the purchase decision process is almost automatic. Previous purchases lead to a routine decision making process. Therefore, the buyer does not consciously choose a product or brand. Especially in terms of goods for daily needs, buyers tend to develop their own routines to minimize the emotional and cognitive effort. Between the perceived stimulus and response—the purchase—there is no additional searching for and processing of information. Habitual decision making is characterized by low emotional and cognitive involvement. While routine processes reduce complexity, the buyer's cognitive control is low. An example of this type of decision is daily food shopping at the supermarket.

Impulsive purchase decisions are driven by emotions that strongly influence the decision making process. Unplanned impulse buying is often triggered by strong activating stimuli, which the consumer responds to by making a purchase. Cognitive involvement is low and emotional involvement is high. The buyer therefore makes a decision based on short-term emotional activation and requires only a very small amount of information about the offer.

Limited decisions occur when the decision making process is shortened due to various reasons, for example, when restricted shelf space in a store limits the buyer's choice. This restricts the final decision process to a comparison of preselected alternatives.

2.2.5 Perception, Attention, and Activation

Due to the abundance of media, an overwhelming number of advertising messages compete against each other. As a result, customer attention is becoming a scarce resource. Thus, disseminating information and getting customers to pay attention both represent fundamental challenges. Difficulty in drawing attention served as a guiding paradigm for traditional advertisers and, for example, led to the establishment of the AIDA model, which describes a basic buying process defined in terms of: Attention, Interest, Desire, and Action (Burmann 2008). Since attention is the first step in the buying process it plays a very central role in successfully selling products.

Advertising messages can be processed only if the consumer consciously perceives them. Therefore, perception, that is to say the process of interpreting sensory stimuli in a way that is meaningful to the recipient, is a basic tenet of successful advertising. Attention is a prerequisite for perception and is broadly defined as a temporary activation that creates in the individual an awareness of certain stimuli. In sum, perception, attention, and activation are important basic aspects of successful advertising campaigns (Lanham 1994). Activation describes an individual's inner state of awareness. From a physiological point of view, activation is the stimulation of the central nervous system that leads the human organism into a state of motivation and higher performance. The extent of activation influences the responsiveness, efficiency, and performance of an organism. Performance relates primarily to cognitive processes, such as the acquisition, processing, and storage of information. Activation can generally be triggered in three ways: on a physiological level, on a subjective experience level, and on a motor level. Up to an optimal level of activation the following rule applies: the more powerful the activation, the higher the cognitive performance of the individual and the greater the amount of information that can be processed. However, if the optimal level is exceeded, the organism's responsiveness and efficiency declines. In order to develop sustainable advertising campaigns, it is therefore important not to over-activate. In addition, higher-activation ads are generally remembered longer but the extent of activation has no bearing on whether the ads are perceived positively or negatively. The following rule applies: if the activation of a message is stronger, the consumer will process it more efficiently but qualitative communication success is not necessarily associated with stronger activation (Kroeber-Riel and Weinberg 2003).

2.2.6 Emotions and Experiences

The use of emotions is very common in advertising since people remember situations better based on emotions rather than factual information. In addition, emotional experiences have become an important reason for why consumers choose a particular product or brand (Franzen and Bouwman 2001). Accordingly, marketers

have established the concept of experience marketing (Pine and Gilmore 1999) that aims to create value from the emotional experience offered by the product or brand. Smoking Marlboro promises the experience of freedom and adventure. The value of the individual experience is defined as a subjective contribution to the quality of the consumer's life. Advertising, therefore, often seeks to awaken emotions in potential consumers. This is based on studies showing that products that trigger emotions are considered more intense, lead to improved processing and memorizing of messages, potentially produce a better brand image, and enable a clearer differentiation from alternative offerings. In communicating emotions, a distinction is made between extent and quality. The *extent* of emotions is relevant when an emotional experience is supposed to activate consumers. As described, activation should lead to higher performance and enable the consumer to process more information. The *quality* of emotions is relevant when a product or brand is supposed to be linked with particular emotions. In the hearts and minds of consumers, specific emotional experiences are to be connected to an offer, and both emotion and offer are to be linked in the long term. Examples of specific emotions are social acceptance, eroticism, freedom and adventure, nature and pleasure, pleasure, happiness, and companionship (Kroeber-Riel and Weinberg 2003). A product or brand should thus provide the buyer with selected emotional feelings.

2.3 Developing Advertising Programs

The development of advertising programs consists of five steps: setting objectives, establishing a budget, choosing and creating the message, selecting the media-channels, and, finally, evaluating the results. These five steps are known as the "5Ms" of advertising: Mission, Money, Message, Media, and Measurement (Kotler and Keller 2008).

2.3.1 Mission

Defining the advertising objective is determined by the target market and the positioning established by the organization's marketing strategy. The objective or advertising goal is the desired result of the communication process between advertiser and recipient within a given timeframe. According to the advertiser's needs and aims the objectives can be classified as shown in Table 1 into cognitive, emotional, and conative advertising goals.

2.3.2 Money

Defining the budget is generally determined by the product's life cycle, the existing consumer base and market share, competition, buying frequency, and the substitutability of the offer. Of course, the budget varies widely with the media and technologies used.

2.3.3 Message

Developing the advertising message and positioning the advertisement is a creative and an analytical task. Using market research, advertisers learn about how, when, and where their target audience will most likely perceive their message. Based on this knowledge they decide the position, frequency, and other aspects of the advertising message. The actual creation of the message, that is to say the design, layout, logo etc. is the creative part of the development process. The latter is just as important for the advertisement's effectiveness: "The ad's impact depends not only on what is said, but often more importantly, on how it says it" (Kotler and Keller 2008). In addition, as postulated by McLuhan, the medium influences the perception of the message (McLuhan 1964). This is of particular interest when new technologies are used to communicate with potential customers.

2.3.4 Media

Media types vary in aspects such as reach (percentage of the target market exposed to the medium), frequency (e.g., frequency of message display), or impact (e.g., persuasiveness of the medium). In principle, advertisers try to find the best balance between reach, frequency, and impact on the one hand, and corresponding costs on the other. Among the variety of advertising modes and techniques we would like to highlight out-of-home and point-of-purchase advertising. Both are highly relevant to the field of pervasive advertising.

Out-of-home advertising refers to a range of advertising methods designed to reach people in their everyday environments. Most of these environments are public or semi-public areas in which regular activities such as working, shopping, or traveling take place. Typical environments are shopping malls, airports, train stations, or city centers. Frequent types of out-of-home advertising are described by Stalder in this book.

The term point-of-purchase advertising describes ways to communicate with potential customers during the actual act of purchase. Next to classical in-store TV advertising, other forms of in-store advertising include ads on shopping carts, aisles and shelves, in-store demonstrations, or coupon machines. A significant number of consumer purchase decisions take place at the point-of-purchase. Point-of-purchase advertising has a strong potential to remind consumers of certain offers while making their final decisions as well as stimulating spontaneous purchases.

2.3.5 Measurement

The final step is evaluating the results. Has the ad been communicated effectively? In order to measure the communication effect, an advertising objective needs to be set in advance. An advertising objective is, according to Kotler and Keller "a specific communication task and achievement level to be accomplished with a specific audience in a specific period of time" (Kotler and Keller 2008). As described above, these objectives can be classified as cognitive, emotional, or conative.

Different objectives and different advertising media allow different measuring techniques. Whereas measuring the click-through-rate of an online banner is relatively simple, measuring the communication-effect of a newspaper advert is still very complex. This differentiation should be considered when developing new advertising techniques.

2.4 Relevant Changes in Advertising

In the previous sections we presented fundamental marketing and advertising concepts as an introduction for the non-specialist reader. The scientific and practical discussion of the ideas presented shows that the central issues are more complex than first set forth.

For example, in addition to the categorizations of "above the line" and "below the line" (2.1.3), which are rooted in the advertising industry, complementary approaches take into account that the advent of digital technology led to a higher fragmentation of the media landscape and an extensive growth of "touchpoints" between advertiser and consumer. Today, advertisers make use of an increasing variety of promotional instruments that require a more sophisticated categorization. This is especially true for pervasive advertising and many of the new developments we present in this book. Nevertheless, we think the categorizations of "above" and "below the line" provide a useful point of reference that facilitates the linking of standard advertising approaches with new developments.

In contrast to the broad definition of marketing we presented in 2.1.1, the standard definition of advertising as a "paid" presentation and promotion (2.2.1) seems to have a crucial limitation. The restriction to paid activities means that advertising is limited to a specific type of presentation as well as specific type of distribution. Particularly, the term "paid" refers to advertising that is distributed through channels that are not owned by the "identified sponsor," i.e., the advertiser. The advertiser pays for time or space in an advertising channel operated by someone else in order to present or promote his message to an audience. Hence, the standard definition of advertising implies that advertising channels are always owned by an external operator. Whereas this was mostly the case for mass media channels such as television, newspaper, or radio, the situation has clearly changed

with the spread of digital information and communication media. Therefore, in this book, we expand the standard definition to include presentation and promotion through advertising channels owned by advertiser themselves, such as in-store screens or shopping assistance devices.

Accordingly, for scientific and practical work concerning the fundamental concepts presented here, this introduction can only serve as a starting point for a substantive discussion of the latest developments. Some of these developments are presented in detail in the following chapters of this book.

This is of particular importance with regard to the realities of ongoing digitalization. While the digitalization of communication processes continues to progress in business and society, a new wave of digitalization in the field of marketing and advertising can be observed. In recent years, a wide variety of new advertising media, communication channels, business models, and use forms have been established. Now the continuing proliferation of digital communication media leads to far-reaching changes across entire industries. While some industries have been experiencing this change for some time, others have only just begun to respond.

In contrast to the speed at which practical applications have taken hold, it seems that study of "digitalization" in research-based disciplines, such as marketing research, marketing strategy, or online advertising has lagged behind. This is particularly true in marketing and advertising fields. The latest developments in the fundamental concepts presented above define "digital marketing" in very limited ways. Kotler et al. (Kotler et al. 2007), for instance, only describe indirectly the concept of online marketing as an extension of direct marketing. A systematic adjustment or development of the basic theories and models has, for the most part, still not been undertaken (Kotler et al. 2007, Meffert et al. 2007). These studies also clearly demonstrate that online marketing activities are usually only assigned to the area of communication (or promotion). This view has been largely influenced by online advertising such as banner ads or search engine advertising that allow a very targeted approach of defined target groups. However, the impact of digital media on the overall marketing mix is usually not taken into account. Such methods typically serve as the core of the underlying business model, such as with eBay or Amazon.

In recent years, the wide availability of digital communication technologies not only led to an extensive cross-linking of companies, such as extended value chains, or electronic data processing (Wigand et al. 2007), in many places consumers also become involved in the internal processes of the value chain itself (Tapscott and Williams 2008). The development of social media continues this trend, and transmits it to the great mass of consumers (Shirky 2008). These consumers take advantage of the open structures of social media in order to participate in the production of (user-generated) content. This applies in particular to the field of advertising (Li and Bernoff 2008) but also to the development of new products (Howe 2008), in which consumers are increasingly involved in more direct ways.

3 Pervasive Computing

The following section is intended for readers unfamiliar with pervasive computing. In introducing the field we emphasize the technologies and concepts we consider to be the driving factors behind pervasive advertising. The concept of and term "Pervasive Computing" (we use this term synonymous with "Ubiquitous Computing") goes back to Marc Weiser's visionary paper in the early nineties where he comes to the conclusion that "…the most profound technologies are those that disappear. They weave themselves into the fabrics of everyday life until they are indistinguishable from it" (Weiser 1991). The manner of working at XEROX Parc at that time served as a precursor to the impending future era of computing in which users are surrounded by multitude computers in everyday situations. Schmidt defines pervasive computing as follows:

> **Pervasive [or ubiquitous] computing** describes the trend that interconnected computational devices become interwoven with artifacts in our everyday life. Hence, processing, sensing, activation and communication are embedded into devices and environments, making computing an integral part of our life (Schmidt et al. 2008).

As myriad numbers of small processors and sensors—integrated not only with household appliances, toys, tools, and clothes but also price labels, receipts, product packages, and shopper loyalty cards—spread throughout our environment, pervasive computing has become the subject of highly progressive research in applied computer science.

In this section a brief historical overview is presented and followed by an illustration of technical advances concerning processing power, storage, networking, sensors, and actuators. The remainder of the section will address concepts of automation, interactivity, and ubiquity, made possible by the previously presented technologies.

3.1 Historical Background

According to Weiser, three main eras (see Figure 1) have shaped the computing age thus far (Weiser and Brown 1998). When recalling the *mainframe era*, the image comes to mind of huge computers operated by experts behind closed doors. Computational power was a scarce resource, which had to be shared among fellow users. Mainframe computing is still relevant today (e.g., super computers for weather simulations), but has been largely eclipsed by the PC, whose introduction in the early 1980s ushered in the *personal computing era*. By 1984 as many people were using personal computers as were sharing mainframe computers. Com-

puters became individualized, even intimate devices, which required considerable attention to operate. With the advent of the Internet, people, their PCs, and all kinds of peripheral devices became interconnected, hence creating a distributed medium. The *pervasive computing era*, in which we currently live, is characterized by constant, mass computer use, including the hundreds of computers accessed while browsing the Internet or using a mobile phone, as well as those integrated into cars, buildings, clothes—literally everywhere.

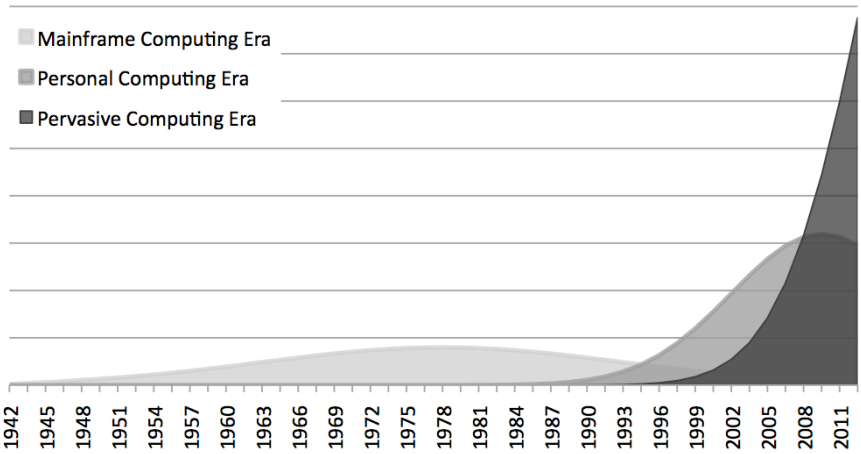

Fig. 1 The three eras of computing (Mainframe Computing Era, Personal Computing Era, Pervasive Computing Era)

3.2 Technical Advances

In the following section we introduce technical advances in processing power, storage, networking, sensors, and actuators that form the basis of the pervasive computing field and are relevant to pervasive advertising.

3.2.1 Processing, Storage, and Networking

For a number of years advances in the implementation of computing hardware have led to exponential increases in processing power, storage, and network capabilities. These developmental trends are referred to as Moore's Law (processing power), the Storage Law (storage and memory), and the Fiber Law (network bandwidth). See (Brown 2001) for a more comprehensive overview. As a consequence of such developments, devices are rapidly getting smaller and more power-

ful and now surround people in their everyday lives, enabling access at any time and place.

Most importantly, the ability to pack increasing numbers of transistors on an integrated circuit led to a massive boost in computational power that has doubled approximately every two years. This trend has continued for more than half a century and still holds true today. The capabilities of many electronic devices are strongly linked to Moore's Law, such as processing power, memory capacity, and even the number and size of pixels in digital cameras. All of these are increasing at exponential rates as well. This has dramatically increased the usefulness of digital electronics in nearly every segment of the world economy. Moore's Law describes a driving force behind technological and social change in the late twentieth and early twenty-first centuries. Apparent today is that processing power, storage, and bandwidth may no longer be a barrier to what computers can achieve in the future. For the most part, the capacities of desktop computers are currently underused, even when writing numerous emails, surfing the Web, or editing images. Hence, increasing processor speed will most likely not increase productivity. Instead creativity, rather than technology, will be the main bottleneck for future system development.

As a consequence of the exponential development described above, the ability emerged to integrate all components of a computer into a single chip (integrated circuit), often referred to as "system-on-a-chip" (SoC) or microcontroller. This chip may contain digital, analog, mixed-signal, and often radio-frequency functions. A typical application pertains to the area of embedded systems. Microcontrollers usually have very limited computational resources and run a single custom program. In modern cars dozens of microcontrollers are used, such as for controlling the engine or windows. Systems-on-a-chip typically use powerful processors, capable of running operating systems such as Linux, and are, for example, used in smartphones.

Popular examples for experimental hardware implementations include Arduino[2] (microcontroller) or the Beagle Board[3] (SoC). Such systems allow different types of sensors and actuators to be hooked up easily, and therefore enable the building of interactive systems in a small form factor.

3.2.2 Sensors and Actuators

The increasing prevalence of smart environments requires the integration of more and more sensors for obtaining information on the environment. The information collected is then processed further and used to modify the environment through the use of different types of actuators. Sensors can either be integrated with the infrastructure (e.g., allowing for information to be gathered on weather conditions,

[2] Arduino Website: http://www.arduino.cc/ [accessed 23/03/2011]

[3] Beagleboard Website: http://beagleboard.org/ [accessed 23/03/2011]

traffic congestion, etc.) or personal devices. Mobile phones, for example, now come with many integrated sensors (GPS, cameras, microphones, digital compasses) that enable the user to collect individualized data while controlling access to this information at the same time. The following section provides a brief overview of sensor and actuator technologies.

A range of *optical sensors* (from motion detectors to cameras) are available, which makes possible collecting very simple (motion-related) but also very complex (human-behavioral) information. The (semi-) automatic analysis of camera images is called computer vision. Today, cameras are so inexpensive (they cost only fractions of a dollar to produce) that they can be integrated into virtually any device. With systems-on-a-chip, processing power and storage can be directly integrated with the camera. Hence, integrated systems can be built, which, for example, only output the number of detected faces, therefore preserving user privacy. In order to analyze the three-dimensional composition of a scene, stereo cameras are traditionally used. In addition to the normal camera image, a depth map is calculated that provides the distance of all objects in the camera's visual field. Stereovision relies on good features (e.g., textures) detected in the image and verified in both camera images (similar to the human visual system), and requires considerable processing power. Recently, so-called depth cameras are available, which generate depth maps by illuminating the scene with special (infrared) light. Two general technologies prevail: (1) Time-of-flight cameras (e.g., SwissRanger 4000 by Mesa) use technologies such as modulated light sources in combination with phase detectors to measure how long it takes light to travel from the camera to the object and back to the camera; (2) Structured light cameras (e.g., Microsoft Xbox Kinect®) project a light pattern onto a scene. A vision system then calculates depth information from the distortion of this pattern relative to the objects in the scene. Using depth images, some operations such as background subtraction are much easier than with normal camera images. The recent price decline in depth cameras has also spawned a significant number of applications, such as in gesture control.

Similar to cameras, *microphones* can either provide low-level information requiring only minimal processing (e.g., noise level, base frequency, characterization of sound source) or high-level information (e.g., speech recognition). Microphone arrays can be used to determine the location of sound sources.

Today *location sensors* can be used to obtain information on position, collocation, and proximity of users both outdoors (GPS, GSM, WiFi, etc.) as well as indoors (Ubisense, Optitrack, etc.). Approaches often vary highly in granularity. Indoors, location sensors are typically embedded in the environment, as with the Active Badge system (Want et al. 1992). In the context of advertising, location sensing can be used for tracking purposes, such as the path customers take through the aisles of a supermarket.

To obtain information on direction, orientation, inclination, motion, or acceleration of a device, many mobile phones now come with *accelerometers* and/or *gyroscopes*. Whereas accelerometers measure proper acceleration of a device

(relative to free fall), gyroscopes measure orientation and rotation (using the principles of conservation of angular momentum) hence making it possible to accurately recognize movement within a three dimensional space. Accordingly, different types of contexts can be ascertained such as the orientation or movement of the device, whether it is stationary on a table or moving in a car. Acceleration is of particular interest when it comes to analyzing usage patterns.

With the advent of the iPhone there has also been a proliferation of devices using *touch* technologies. In addition to smart phones, more and more displays and tabletops are being equipped with (multi-) touch support. Different technologies are used to create touch surfaces. Resistive touch screens use two flexible sheets coated with resistive material, which can register the precise location of a touch as they are pressed together. For capacitive sensing, a conductive layer is used and a small voltage applied to it, hence creating an electrostatic field. When a conductor such as the human hand comes near or touches the surface, a capacitor is formed and the change in capacitance can be measured from the corners of the panel. Optical touch technologies (such as FTIR) use light sensors / cameras and computer vision to detect fingers and objects on and above surfaces. State-of-the-art technologies also include PixelSense (e.g., Microsoft Surface 2.0), a technology where IR sensors are integrated with the LCD display, hence making it possible to see what happens on top of a surface without using a camera. See (Schmidt and Van Laerhoven 2001) for further information on sensor technologies.

Actuators allow information to be output in the form of different representations, for example, via visual, auditory, haptic, or olfactory channels. In the following we introduce the technologies and properties of actuators that address the different channels.

Display technologies include, among others, LCD (liquid crystal displays), plasma displays, projectors, and bendable displays, such as OLED (organic light-emitting diode) displays and e-paper. With the decrease in price of displays, we envision that in the future literally any surface could function as a display with minimal cost. Important properties of displays include size, resolution, readability in sunlight, update frequency, brightness, and flexibility.

For audio presentation, headphones or loudspeakers can be used. Whereas traditional speakers use a horn for increasing the overall efficiency, parabolic loudspeakers use a reflector, resulting in a beam of sound, which can travel farther and be directed to isolated target audiences. Ultrasonic systems use wave interference to create sound that is only audible within small areas, and which can be relatively far from the loudspeakers. When it comes to spatial sound rendering, there are different approaches for generating spatial sound. Whereas stereophonic sound creates the impression of hearing sound from different directions using two independent audio channels, surround sound increases the perceived spaciousness through additional discrete speakers. With both techniques however, the sound essentially comes from one broad direction. In order to create sound coming from arbitrary positions in space, Ambisonics or wave field synthesis (WFS) can be used. WFS mimics natural wave fronts and allows for much larger listening re-

gions than Ambisonics. For example, some large cinemas are currently equipped with WFS. Using WFS, the localization of the sound sources is independent from the listener's position.

Haptics describes the recognition of objects through touch, including tactile perception, proprioception, thermoception, and nociception. For haptics, actuators are used that apply forces to the skin for touch feedback. Such actuators include vibration motors, electroactive polymers, piezoelectric, and electrostatic surface actuation. Haptic actuators are popular in robotics where they serve as the muscles of a robot. Most popular actuators include electric motors, linear actuators, series elastic actuators, air muscles, muscle wires, electroactive polymers, and piezo motors.

Finally, olfactory actuators allow for interaction based on smell. So-called olfactory displays can disseminate odors, hence serving as an olfactory channel between man and computer. For an introduction to olfactory advertising see chapter 17.

3.3 Concepts

The previously mentioned technologies (processing, storage, networking, sensors, actuators) are crucial prerequisites to pervasive computing and make possible its core principles of automation, interactivity, and ubiquity.

3.3.1 Automation

With the industrial revolution many work processes were automated; this automation continues today. More and more mechanical and electro-mechanical systems are now computer-controlled, going beyond what we know as mechanization. This enables so-called scale effects, which lead to lower average manufacturing costs per unit relative to increases in output. As a result, prices for products entering the market decrease as higher quantities are produced. An example of this is the fingerprint reader, which was a very specialized device some years ago but can now be integrated with laptops at little additional expense. Today automation is no longer restricted to manufacturing but has found its way into telecommunications (e.g., telephone switchboards), medicine (e.g., electrocardiography), finance (e.g., automated brokering, ATMs), and also advertising (e.g., Google AdSense).

From a computer science perspective, the ultimate automation would be to create artificial intelligence (AI). The term goes back to 1956, when John McCarthy defined artificial intelligence as "the science and engineering of making intelligent machines" (Crevier 1993). In the beginning the objective was to build a general-purpose AI that can emulate all human cognitive capabilities (strong AI). This was found to be much more difficult than expected, and by now most researchers and

engineers have limited their ambitions to use AI technology only to solve very specific problems (weak AI). AI is, among others, concerned with the following sub-problems: problem solving (e.g., search), knowledge representation and reasoning (i.e., logic, inference and planning, dealing with uncertainty), unsupervised machine learning (i.e., finding unknown patterns in a data input stream), and supervised machine learning (i.e., classification into known categories). Computer vision is mainly concerned with extracting and interpreting information from an image that can later be used to solve a task. Exemplary problems in computer vision are recognition (e.g., recognition of an object, identification, or simply detection) and motion analysis (e.g., for tracking purposes). Similar to AI, it is generally not possible to build a general-purpose computer vision system that can recognize arbitrary things. Instead, one needs to define in advance a specific problem to be solved (e.g., finding faces in an image) and can then use computer vision techniques to solve this task. Foundational techniques for many applications are image acquisition (e.g., recording a video stream from a camera), pre-processing (e.g., re-sampling, noise reduction, enhancing contrast, or scaling), feature extraction (e.g., finding lines, edges, or ridges), detection and segmentation (e.g., selecting a set of interesting points), and some final high-level processing (e.g., image recognition, classification). Computer vision can, for example, be used to find and track people in a video stream, for face detection, face recognition (comparing faces to a database of known faces), interaction (e.g., gesture recognition), or activity recognition (e.g., whether somebody is seated).

3.3.2 Interactivity

Human-computer interaction (HCI) is concerned with "the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."[4] Since its subjects are man and machine, knowledge from computer science, as well as psychology, communication science, graphic and industrial design disciplines, linguistics, social sciences, etc. are all relevant. The driving goal behind HCI is to improve interaction between users and computers given a certain use context, which usually has a strong impact on the usability of a user interface. Hence HCI draws on methodologies and processes for designing and implementing interfaces, techniques for evaluating and comparing interfaces, developing new interfaces and interaction techniques, and developing models and theories of interaction.

When it comes to interaction, two different types prevail. Traditionally, human-computer interaction focuses mainly on *explicit interaction* where the user tells the computer at some level of abstraction what he expects the computer to do, for ex-

[4] Hewett TT, Baecker R, Card S, Carey T, Gasen J, Mantei M, Perlman G, Strong G and Verplank W: ACM SIGCHI Curricula for Human-Computer Interaction. http://old.sigchi.org/cdg/cdg2.html#2_1 [accessed 23/03/2011]

ample, by directly manipulating an object using a mouse, touch screen, or speech input. Yet, as HCI extends beyond the desktop, *implicit* interaction, that is interaction occurring without the explicit intention or awareness of the user, will become ever more important. Schmidt defines implicit interaction as "an action, performed by the user that is not primarily aimed to interact with a computerized system but which such a system understands as input" (Schmidt 1999). For example, a display may recognize that the audience is smiling and consequently display funny content.

Since the rise of HCI in the eighties, several design methodologies have emerged. *User-centered design* is a design philosophy, which puts the user at the center when designing any computer system. As a result, users, designers, and technical practitioners co-operate in order to address users' wants, needs, and limitations to create a usable system. Norman presented six *principles of user interface design* (Norman and Draper 1986) to be considered during all stages of the design process (visibility, feedback, affordance, mapping, constraint, and consistency).

An important part of HCI is the *evaluation of user interfaces*. Traditionally, empirical measures with regard to usability are time to complete the task(s) and the number of errors made during the task(s). Usability is defined by ISO as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." Stated differently, usability is a measure for how easy a user interface is to use. Jakob Nielsen (Nielsen 1994) and Ben Shneiderman (Shneiderman 1998) presented frameworks of system acceptability, outlining learnability, efficiency, memorability, errors, and satisfaction as crucial factors for user interface design. Whereas many traditional interfaces are used to solve concrete tasks, this is often different for advertising. Here, content is often perceived rather passively, or playful interfaces are used as toys. For a general introduction to HCI see (Dix et al. 2003, Card et al. 1983).

Recent developments in *computer graphics* allow creating impressive images on displays. Computer graphics is a subfield of computer science and is concerned with the methods of digitally synthesizing visual content. Generally, a distinction is made between interactive computer graphics, which may take a few milliseconds to generate an image at most, and non-interactive computer graphics, where the generation of a single image can take up to several hours (e.g., for movies). Two-dimensional and three-dimensional graphics are possible; three-dimensional graphics are also often rendered on a flat screen. For three-dimensional graphics, two general technologies prevail. Rastering techniques (e.g., OpenGL) use mathematical projections to display primitive three-dimensional shapes such as triangles on a flat screen. Similar methods are used to generate shadows, reflections, etc. Ray tracing tries to follow each light ray that hits the screen backwards through the scene to the light sources in order to determine its color. Using rastering techniques, today's massive parallel programmable graphics hardware allows for unprecedented real-time realism in computer graphics.

With the market penetration of the smart phone and other related devices, the notion of layering relevant information into our visual field (*augmented reality, AR*) became a hot topic in HCI. AR describes hereby the live direct or indirect view of the physical world whose elements are augmented with computer-generated, sensory input. In general, AR requires computer vision and object recognition in order for the real world of the user to become interactive and digitally manipulatable. Examples of AR applications include navigation systems that allow views of the road to be augmented with cues on direction, points-of-interest, and upcoming obstacles. Furthermore, social interaction may be augmented in the future by providing additional information about the people we're conversing with by projecting such data onto our glasses.

3.3.3 Ubiquity

The ubiquity of pervasive computing technologies is one of their most profound properties. Computers that integrate information processing into everyday objects and activities as well as new generations of the Internet allow people to get in touch with one another at any time and place. Accordingly, this makes information-rich technologies and applications possible and further adds to Mark Weiser's vision of "Ubiquitous Computing".

Mobile and wireless computing devices now come with high-resolution cameras, integrated GPS, and provide easy access to the Internet. Similarly, the TV is also linked to the Internet and is no longer restricted to a single location (at home). As location-independent digital media entertainment becomes available with devices such as smart phones or tablets, younger generations in particular are eager to adopt these technologies.

Beyond mobile devices, more and more processors and sensors are integrated into everyday objects, such as household appliances, tools, toys, and clothes. When linked through wireless networks, they create the so-called *Internet of Things*. This allows users to easily connect to social networks and virtual worlds and makes possible novel forms of applications and services that augment the physical world through new forms of interaction and communication.

4 Pervasive Advertising

After decades of development in the laboratories, pervasive computing technologies are finally in a position to reshape our world. Analogous to developments on the Internet, it is our belief that advertising will be the business model that drives pervasive computing. As illustrated above, the goal of advertising is to impart information, evoke emotions, and trigger actions. The properties of pervasive computing (automation, interactivity, ubiquity) make it a powerful tool for achieving

these goals. These properties have the potential to change advertising in six main ways: symmetric communication, long tail, experiences, personalization, audience measurement, and automated persuasion.

As stated previously, advertising is defined as any paid form of non-personal presentation and promotion of ideas, goods, or services by an identified sponsor. Pervasive computing environments are saturated with computing and communication capabilities, yet these features are integrated so seamlessly for the user that it becomes 'the technology that disappears.' Based on these definitions, we define pervasive advertising as:

> Pervasive advertising is the use of pervasive computing technologies for advertising purposes.

4.1 Pervasive Advertising Technologies

It is our belief that among the technologies developed by pervasive computing, three hold the most initial promise for pervasive advertising: digital signage, mobile phones, and physical computing/robotics. Certainly, the main value will be created not when these technologies are used on their own, but when synergies emerge from their combination.

4.1.1 Digital Signage

Digital signage, as developed in pervasive computing, has obvious potential to make out-of-home advertising digital (Müller et al. 2010). Stalder and José touch upon this aspect in their chapters on the digital signage advertising market. In a similar vein, de Carolis takes on the issue of displays in fitness clubs, while Taylor addresses displays in villages, and Schrammel and Reitberger displays in public transportation and shops, respectively. Digital signage distinguishes itself most significantly from mobile phones in that the hardware is usually not owned by the audience. The audience is merely passing by or waiting in the vicinity of the display and decides whether to look at or interact with the display. The audience only has limited influence over the content displayed.

4.1.2 Mobile Phones

The second most promising technology for pervasive advertising is the smartphone. In contrast to digital signage, mobile phones are owned by individual users. Accordingly, the audience itself decides what content is shown and what ap-

plications are installed on the phone. Since the private phone is considered a very personal device, audiences may be more sensitive to advertising. On the other hand, people typically own their phones for long periods of time. Unlike digital signs, which are usually experienced in brief intervals, mobile phone owners carry their devices with them at all times. Smartphones are equipped with a variety of sensors and can store very personal information, such as address books and emails. These properties may enable strong personalization and context adaptivity, as explained in Partridge's chapter. At the same time, this makes privacy protection a goal of primary importance, as Haddadi describes.

4.1.3 Physical Computing / Robotics

Beyond digital signage and mobile phones, pervasive computing aims to digitalizing our entire physical environment. This can start from simple markers in the environment (e.g., QR codes or NFC), as explained in Wakeman's chapter. Another aspect is control of lighting and simple robotic devices. An example of this is the Philips smart shop window (Kessels et al. 2009) in which products rest on interactive turntables that rotate to present the products to the audience. Mobile robots, that is, robots that can walk or roll around, can also act as salespersons. For example, Kanda (Kanda et al. 2008) describes a robot that has been used to approach people in front of a shop and lure them inside. Going a step further, such physical computing environments can appeal to all our senses, such as using sound, as shown in Meier's chapter, or even smell, as explained in Emsenhuber's chapter.

4.2 Opportunities

Pervasive computing is set to change the face of advertising in major ways. When applied to this field, pervasive computing's automated, interactive, and ubiquitous properties translate into novel forms of advertising. Pervasive advertising distinguishes itself from traditional advertising in six different ways, its unique opportunities include: symmetric communication, the long tail, experiences, personalization and context adaptivity, audience measurement, and automated persuasion.

4.2.1 Power to the People (Symmetric Communication)

Classical advertising follows a mass media approach in which a small number of advertisers distribute their advertisements to the masses. This unidirectional communication model produces an asymmetrical distribution of power. All the power is concentrated in the hands of advertisers who decide which ads to show when and where. At best the audience has the option to ignore, protest against, or van-

dalize the resulting ads. For some people, such an asymmetrical distribution of power creates a feeling of being at the mercy of advertisers.

Since pervasive computing is interactive it offers the opportunity to transfer a significant degree of power to the audience. This fundamentally alters the unidirectional communication model by allowing the audience to communicate opinions directly to advertisers and other audiences. Companies must treat customers as equals. This can benefit both consumers and companies since a closer bond is created between the two and because it allows companies to learn from their customers much faster. Practical examples include the ability of the audience to choose the content they like and even to submit their own content. Eventually, this may lead to a democratization of advertising and the look of public spaces (see van Waart's chapter). Also, social media will foster communication within communities, as Dubach-Spiegler, Wakeman, and Taylor explain in their chapters.

4.2.2 Me, Too (The Long Tail)

By definition pervasive computing is highly automated and many things that required individual attention in classical advertising will also become automated. This significantly lowers the cost of and effort needed to produce individual advertising campaigns. Starting a new campaign may be as easy as filling out a few fields on a website and may cost only a few cents. This price decline enables very small companies and even individuals to launch their own tiny, local campaigns. It is important to remember that not only big companies are interested in advertising as the communication of sponsored messages. Even a small restaurant or market stall must advertise, just like anyone who wants to sell an old bicycle. Even someone who wants to surprise his wife at an airport or make a present for a birthday might be interested in displaying something in public, similar to someone who wants to impress his friends. Some examples of how to accomplish this are presented in José's chapter.

4.2.3 The 'Wow' Effect (Experiences)

Pervasive computing offers powerful media that respond to all senses. Large, bright displays that surround us create powerful visual impressions, but it is also possible to appeal to our hearing, what we feel, haptics, and even our sense of smell. As Norman (Norman 2003) explains, there are three levels to interactive computer systems. The lowest level is visceral, in other words, what initial visual impression the technology makes. This can be described as "the first impression." The second level is behavioral, related to the look and feel, and described as "how it feels." The third level is reflective, for example, what we think others think about us when we use it. Since most traditional ads are not interactive, they do not go beyond the first level. Pervasive advertising, however, needs to properly ad-

dress all three levels. It has a look and feel, and also makes us reflect when we interact with it. These properties make it a much more powerful tool for advertising. Since pervasive computing is all around us, these experiences can follow and surprise us wherever we go. Furthermore, since pervasive advertising is digital, it is very easy to create new experiences all the time. Together, this makes creating a wow-effect possible over and over again. Analog posters will look relatively pale compared to the intense and memorable experiences that can be created with pervasive advertising. Examples of what this can look like are presented in van Waart's chapter.

4.2.4 Just for Me, Just for Now (Personalization and Context Adaptivity)

Personalization and context adaptivity are at the core of pervasive computing and provide natural powerful tools for advertising. In personalization / user modeling, computers learn the preferences and behavior models of groups or individuals. This fits naturally with the target groups as a core concept of marketing. It is important to remember that in marketing, target groups are used in different ways: for the development of the product as well as for the placing of the advertisements. The dilemma of advertising traditionally was that the properties defining the target group have to be measurable, and target groups have to be accessible based on these criteria. This restricts them basically to demographics and other easily assessable criteria. Pervasive computing allows many more things to be quantified, thus making it feasible to develop target groups based on measurable demographic criteria or actual behavior. Pervasive computing allows measuring all kinds of things in real time, building user profiles, and adapting advertisements, thus making accessible far more finely tuned target groups. Partridge and de Carolis address these issues in their chapters.

In addition to personalization, adaptation to the context becomes much more fine-tuned because of automation and better sensors. Traditionally, a huge effort was required to post different ads, for example, depending on the weather. Using pervasive advertising, however, such things as advertising ice cream when the sun is shining and umbrellas when it is raining become minor. It can be assumed that when advertisements are much better adapted to the context, for example, when showing products in the hometown context of the audience, they are more effective. Bauer and Strohbach describe in detail how this can be achieved in their chapters.

4.2.5 Did You See Me? (Audience Measurement)

Audience measurement has always been an integral part of advertising, mainly because "if you cannot measure, you cannot improve." Any advertising campaign is driven by goals, and goals can only be set according to factors that are measurable.

Limited measurement capabilities also limit the scope of what one can try to achieve. Pervasive computing provides powerful sensors for measuring, for example, the actual behavior of people. To see the immense opportunities this provides one only needs to briefly consider the Web. Because clicks are easily measurable, whole new business models and paradigms have emerged. Ads are often paid for on a click-through basis. Campaign success is completely transparent using tools such as Google analytics, enabling advertisers to optimize and cancel campaigns based on live data. Even the fully automated optimization of advertising campaigns is possible, using tools such as Google Website Optimizer, which can automatically run statistical tests on user behavior in different versions of campaigns and optimize the campaign accordingly.

Pervasive advertising makes it possible to apply this entire approach to the real world. User behavior, for example, whether people looked at an advertisement, can be easily measured using computer vision and face detection. Tracking when audiences interact with the ad is basically free, and even such things as eye tracking may soon be ubiquitous. This will allow advertisers to set goals that are far more detailed (e.g., 50% of bald men between forty and sixty should have read the first sentence in this text block advertising hair implants), and optimize their campaigns in a rapid loop. If it were possible, for example, to track that many people frown and turn away after seeing a specific part of an ad, one might try to find out why and make adjustments. As a result, advertisers can determine which aspects of an advertisement the audience prefers and adapt their campaigns accordingly. Details on audience measurement for digital signage are presented in Schrammel's chapter.

4.2.6 Wouldn't You Like This? (Automated Persuasion)

Persuasive technology is defined as "using computers to change what we think and do" (Fogg 2002). Persuasion stands in opposition to coercion, because no formal pressure is used. Of course, persuasive technology is not only limited to advertising but also has important applications in healthcare and education. It can, for example, help people quit smoking or encourage them to learn. Fogg distinguishes *macrosuasion*, where the whole intent of a product or service is to change intentions and behavior, and *microsuasion*, where persuasion is used to accomplish small steps for a product or service with a different intention. The advantage of computers over traditional media is that they are interactive, and in contrast to human persuaders they are more persistent, allow anonymity, process large amounts of data, use multiple modalities, and are scalable and pervasive. Computers can function as tools, media, or social actors. As tools, they can persuade by reducing complexity, tunneling the user into predefined action sequences, tailoring and personalization, offering suggestions at opportune moments, simplifying the self-monitoring of users, giving users a feeling of being observed, and operant conditioning. As a medium, they can persuade by putting the user into simula-

tions. As a social actor, they can persuade through physical cues such as attractiveness, psychological cues such as similarity to the user, language (e.g. praise), social dynamics (e.g. reciprocity), or by taking social roles (e.g. authority). In order to persuade, a system must be perceived as credible, in other words, that it is trustworthy and possesses expertise.

Since advertising aims to change attitudes and behaviors among other things, it should come as no surprise that persuasive technology is ideally suited to this field. For example, an advertisement might try to persuade a customer to buy a specific product over another, or to promote a general preference for certain kinds of products. An overview of how digital signage can persuade target audiences is presented in Reitberger's chapter.

4.3 Challenges

After presenting the foundations of advertising and pervasive computing, and the opportunities of pervasive advertising that result from their merging, we would now like to return to the challenges touched on at the outset. It is our belief that we must solve together the challenges presented by calm and engaging advertising, privacy issues, and ethical persuasion in order to guide the development of the field in a future positive direction.

4.3.1 Advertising Needs to be Calm and Engaging

That technology should be calm and require minimal attention has been a core feature of pervasive computing from its very inception. In their seminal paper on calm computing, Weiser and Brown (Weiser and Brown 1998) propose that, when computers saturate the surrounding environment, calm computers will be most effective. Key to this is the effortless sliding of information between the center and periphery of our field of attention. This idea has strongly influenced research for decades, and initially the underlying paradigm was that systems should remain invisible, predict the requirements and wishes of users from data obtained with various sensors, and then 'magically' perform some actions like suppressing phone calls or switching on the light. Over the years, it became clear that predicting what users want through observation alone is very difficult or perhaps even impossible. In response to her observation of these facts Rogers proposed the seemingly oppositional paradigm of engaging computing: computers should provide great experiences and engage users more in how they currently behave.

It is our belief that pervasive advertising should be both calm and engaging. Although this might seem like a contradiction, it is not. Calm advertising means that advertisements should be easy to ignore. Engaging advertising means that ads should provide engaging experiences when one is actively engaging with them.

This can be achieved at the same time. A pervasive ad could appear as calm, mildly flowing water when nobody engages with it, and then convert to an engaging mini-game once somebody pays attention. Partridge's chapter provides examples of how context adaptivity can be used to create calmer ads.

4.3.2 Privacy Has to be Guaranteed

Like calm computing, privacy has been an important topic for pervasive and context-aware computing from the beginning. Most systems center on the fair information principles (see chapters by Geiger and Haddadi) of notice/awareness, choice/consent, access/participation, integrity/security, and enforcement/redress. A variety of systems (like pawS) have been proposed to implement these principles in technical systems (Langheinrich 2002).

In pervasive advertising, there is a huge incentive for advertisers to collect as much user data as possible. Thus, it is crucial that user privacy also be protected. This can happen either through industry self-regulation, lawmaking, or both. The degree to which privacy is protected and guaranteed will determine whether users trust advertisers. Winning such trust requires effort and is also easily lost; guaranteeing user privacy is one of the foremost challenges facing pervasive advertising.

4.3.3 Persuasion Needs to be Ethical

With regard to ethics, Fogg (Fogg, 2002) mentions six significant ways in which persuasive technology can be abused. For example: the novelty of the technology may mask the persuasive intent; the positive reputation of computers may be exploited; computers can be proactively persistent; computers control the interactive possibilities; they can affect emotions but are not affected by emotions; and, finally, computers cannot shoulder responsibility.

It is said that intentions as well as methods and outcomes of persuasion can be ethical or unethical. Deception and coercion are always unethical, while operant conditioning and surveillance raise a red flag. Furthermore, it is unethical to persuade vulnerable groups like children. The method proposed to analyze ethics is known as stakeholder analysis, where all stakeholders are listed as well as what they have to lose. It is then evaluated which stakeholder has the most to gain or lose, and the ethics are determined by examining gains and losses in terms of values. Finally, the values and assumptions that are brought to the analysis should be acknowledged.

Persuasion is an integral part of advertising, and ethical use of persuasion is an important challenge facing pervasive advertising. With regard to advertising, it is our belief that any intention to persuade audiences against their own interests is unethical. Similarly, persuasion of vulnerable groups is unethical, as well as all

methods that are deceptive, use coercion, operant conditioning, or surveillance. Again, details on persuasion are provided in Reitberger's chapter.

5 Conclusion

In this chapter we saw that advertising is any paid form of non-personal presentation and promotion of ideas, goods, or services by an identified sponsor. Advertising aims to inform, evoke emotions, and trigger actions. Pervasive computing describes the trend in which interconnected computational devices are interwoven with artifacts in our everyday life. Pervasive computing enables automation, interactivity, and ubiquity. When pervasive computing technologies are used for advertising purposes, we call this pervasive advertising. The greater effectiveness and efficiency of pervasive advertising over traditional advertising forms will be the key to its success. The six most important opportunities of pervasive advertising include: it shifts more power to audiences and consumers, leading to symmetric communication between them and advertisers. It makes even tiny advertising campaigns viable, leading to a long tail of many small advertisers. It provides much more engaging experiences than traditional advertising. It enables ads to adapt to the audience and the context. It enables detailed audience measurement, and finally, it enables advertisements to employ automated strategies for persuading audiences. We believe that pervasive advertising is coming, and that our greatest responsibility is to shape this development in a meaningful way. We see three important challenges: First, we should strive for calm advertising—ads that do not disturb audiences when they are not interested, while still providing engaging experiences for those who are. Second, we need to respect the privacy of audiences and build privacy-preserving architectures into the foundation of any pervasive advertising system. Third, while advertisements may try to persuade customers, the method of persuasion must always be overt, and may never employ unethical means to achieve its goals. We hope that this book is useful in bringing advertisers and pervasive computing people together and providing a foundation for the approaching era of pervasive advertising.

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