Technological and Business Challenges in Pervasive Computing

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1. Pervasive Computing

According to the panel description, pervasive computing deals with environments "where computing and communication capabilities are embedded in everyday objects and gracefully integrated with human users." At the front end of a pervasive environment, devices are installed to collect information from the physical world and react to actions from human users or other devices. Behind the front layer, information is continuously received, digested, organized and synthesized in order for the system to respond to the real world. At the end, actions are taken that physically impact the real world. Soft actions may take place by merely providing information to users for them to initiate the physical actions. Hard actions, on the other hand, are taken by the devices directly (e.g., switching off lights)

Having framed the problem it is not difficult to see that the construction of such an environment is technically challenging but yet remains an achievable goal, thanks to the advances in wired and wireless communication technologies, micro-mechanics and the ever increasing power and shrinking size of computing devices.

2. Time, Space and Context Awareness

In the above description, the physical world is regarded as a single global space. In reality, physical spaces are typically divided into logical units (e.g., rooms) that are often isolated from each other. This creates contexts which involves time, space and social components. In essence, the contextization of an environment allows the system to better predict the actions, and consequently the needs, of a user or a user community. For example, most people are influenced by what are happening nearby, in the near future and to themselves, their friends and families, etc. From the system's point of view, it bounds the scale of a problem and facilitate modularized architecture that can be incrementally expanded.

3. Business Applications

In the most basic sense, a business model is the method of doing business by which a company can , generate revenue. Finding the right business model is the key to the success of all businesses, online or offline. The success of a business model also depends on the execution of the model, e.g., whether costs can be contained and revenues be expanded. In my opinion, that is where the benefits of pervasive computing come in.

For traditional businesses, a pervasive computing environment provides not only a link between customers and businesses anytime anywhere, but an efficient and ubiquitous marketplace where various kinds of information can be automatically gathered and categorized to facilitate the prediction of and matching between supply and demand. To make this possible, the pervasive computing environment should provide a complete "map" of a user's context. In the physical space, the map contains all the interesting objects. In the temporal world, it tracks what actions had been taken by the user and what events happened in the past. In the social world, it also knows which communities the user is in and what happen and are happening around them. This map will be constructed and adapt dynamically along time and space axes.

The availability of the context will provide the user with immediate access to useful information - useful in the sense that it comes out in the right form, at the right time, in the right place - without which the user would find it difficult to initiate a business transaction. For example, my context will contain my travel preferences and tell me where is the nearest bus stop. Without this information, I might have taken another means of transportation (e.g., a taxi, which I can get mostly anywhere) or I might even be discouraged to travel to certain places. All in all, it means business activities are reduced (or at least the pattern will change).

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4. System Vendors and Operators

For system vendors, the enormous scale of a pervasive environment will undoubtedly create great demands on hardware and software systems. We can imagine some common needs. There will be needs for various kinds of sensors, input and output devices, short-range wireless networks to tight devices together, high-speed backbones to allow collected information be transmitted, security systems to produce the information collected and privacy of the user. System operators are needed to ensure the reliable operation of the environment.

5. Service Providers

Service providers are interesting business in pervasive computing because they provides customized applications that ultimately determine the usefulness of pervasive environments. Several possible services are outlined below:

- "Mapping" services: the collection of environmental information, population information, movement patterns, etc., and the creation of clear and extensive maps for the physical environment (street and building maps, etc.). These are the Yahoo! of pervasive environments.
- Personal profilers: the collection of personal profiles via secure portable devices and the selective disclosure of profiles, say, for the completion of a business transaction.
- Wrapping services: interface between "legacy" (i.e., today's) systems and pervasive systems, including conversion, packaging and tagging of information.

6. Research Issues

- New object classes: The transient nature of device connectivity and service availability will open up new problems in modeling, e.g., the definition of classes with non-deterministic membership and redundant members (e.g., a weather service may be modelled as an n/m-redundant class of temperature sensors, where n out of the m class members may be out of service without affecting the normal operation of the weather service). We will also need other object classes for moving objects, personalization objects and resource objects, each of which could be semantically very rich.
- Temporal and spatial constraints: In addition to simple constraints such as constraints on the offering and acceptance of services, pervasive computing environments require complex constraints on the temporal and spatial properties of the environment. For example, a service may be enabled/disabled at a certain time and/or location (e.g., targeted advertisement in a business district). As another example, an object may be required to be at a certain location at a certain time. Pervasive computing will cast new interests in the integrated treatment of active, object-oriented, temporal, and location models.
- Context awareness modeling: Context awareness refers to the properties of a device, including temporal and location properties (e.g., the location of a device and other devices in its neighborhood), and the communities it has established relationships with. Different levels of location abstraction are required. For example, locations can be universally defined as points in a 3-D space or in terms of semantic objects (e.g.,rooms, landmarks, highway intersections, etc.) Context awareness also entails tracking and update propagation of context information.
- Service discovery: The task of finding a service for a request based on "best" match is difficult because of the diversity of pervasive environments. The identification of service communities and service rating, using the concept of "community", "hub" and "authority" originated from the WWW community, can be utilized to manage the complexity of service discovery.

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