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Pervasive Nanotechnology

Abstract

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The miniaturization of electronic components, circuits, and systems in the past five decades and the tremendous progress in communication were the technical keys to what we call now "Pervasive Computing". In the breathtaking pace of miniaturization, a "pervasive electronics" emerged, based on the century invention of the transistor in the forties and on the concept of integrated electronic circuits in the sixties. Miniaturization let both the size of electronic components and the energy dissipation in a logic computer operation shrink by about twelve orders of magnitude, let the speed to execute a logic operation increase by six to eight orders, and let the prize to perform a computation decrease by four to seven orders of magnitude. The miniaturized, pervasive electronics was also the key element for a likewise "pervasive" and world embracing communication, from satellite to wireless local area networks.

One notion of Nanotechnology is the continuation of the miniaturization from today's microelectronics to tomorrows nanoelectronics. Even though miniaturization will come to an end in one to two decades and thus offers much more modest perspectives than what we experienced in the past half century, it will change pervasive computing dramatically. We can count on a further reduction in size and power consumption by another four to six orders of magnitude, on a increase of computer speed by a factor hundred and on a substantial decrease of computing costs. What is now desk top becomes pocket size and today's pocket size becomes an implant, somewhere, in a body, you name it. Pocket size Tera bit and desk top Peta bit storage devices might change the way we compute and communicate, new concepts of computation, e.g. for pattern and speech recognition, respectively, might revolutionize the way we interact.

Nanotechnology, however will reach far beyond this conventional, although most demanding aspect of nanoelectronics. The bottleneck of pervasive computing is not so much the data and signal processing per se but the creation, acquisition, and selection of problem relevant data and signals for input and the clever and efficient use of the output. Generally, these "peripheries" are still slow and clumsy compared to processor performance. It is the pervasive execution of such peripheral tasks where Nanotechnology will be at its best. It will provide an abundance of novel bridges working on the nanometer scale between the real world of action and the "virtual" world of data processing. With smart sensors and actuators - understood generally as any type of data and signal creation, acquisition and utilization - it will establish pervasive pathways to and from some type of processing, not necessarily only digital data processing, and to an from our consciousness. Take as a first example local speech recognition, say in a cellular phone. The conventional microphone would be replaced by an artificial ear and some speech generator, both performing a great deal of preprocessing, possibly on a mechanical basis and combined with a storage-processor hybrid of , say Tera bit capacity. You would listen and talk in your own language, so would your counterpart in his own one. Fantastically convenient, but at a big cultural loss. Or take sensing of some molecular species. With the sensing concept "recognize weak by weak and small by small", nanosensors aim at sensitivities of a few to a few million molecules with sensor systems of a few mm in total size.

This opens unprecedented perspectives for pervasive detection and control. A realistic scenario is immediate sensing of some health condition, say a flue, of a person close to you. Again fantastically convenient, but where would it lead to? General avoidance of anybody by everybody who could be the slightest health risk? Pervasive turns into invasive in a much more dramatic way than what we experienced so far with handling or mishandling "personal" data. Taking preventive measures against the misuse of already collected data and data acquisition is one thing, establishing a codex for adequate, socially acceptable immediate personal response to pervasive risks is unlikely more difficult.

Another class of pervasive nanotechnology concerns nano robotics. Recently, some horror scenarios appeared in the daily press describing armadas of self replicating nanorobots gotten out of control. Nanorobots, especially the ones with a high degree of autonomy, open indeed completely new territories with fascinating perspectives. The danger coming from self replicating nanorobots, however, is a very far away utopia and hardly ever becomes reality. Long before will the world seriously suffer from other events.

In summary, pervasive nano technology will open new scenarios of pervasiveness which will require likewise new behavioral attitudes, measures, and precautions.