"Wireless Ecosystems: Building the Next Generation of Pervasive Computing Systems"

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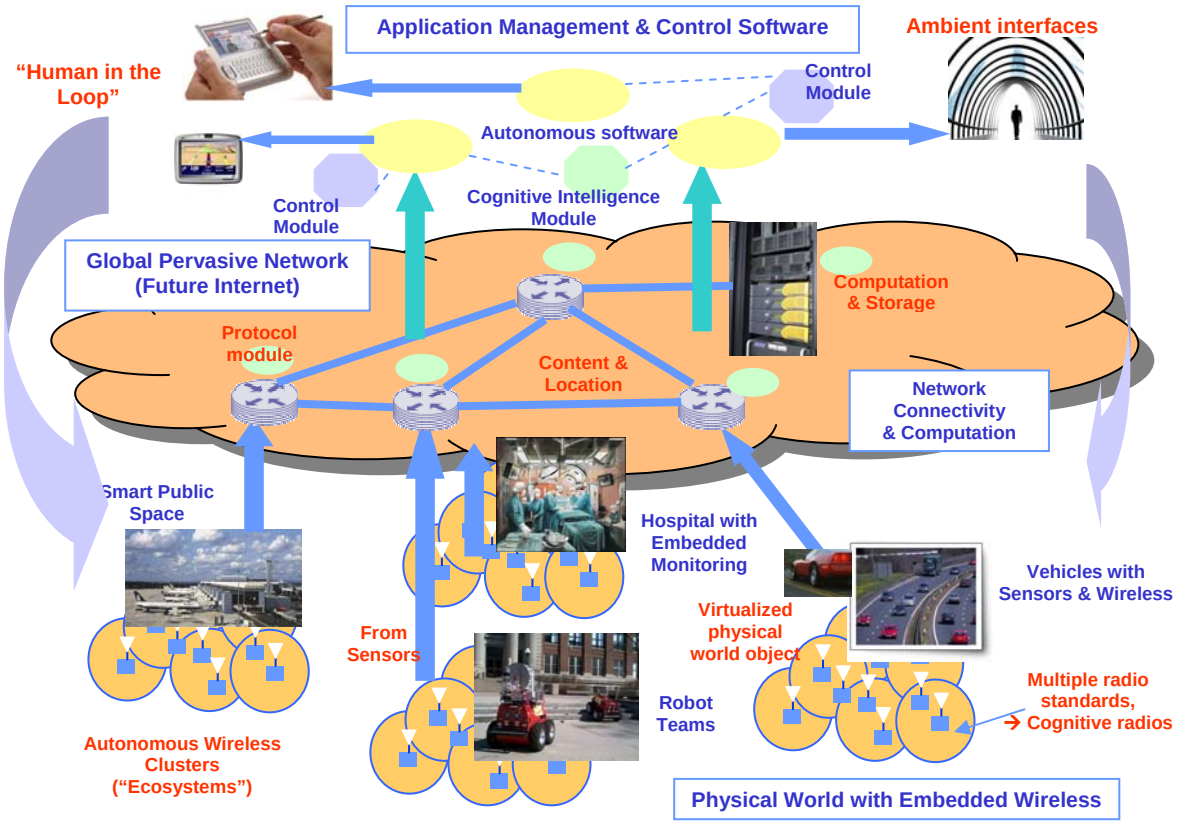
The next major wave of information technology is all about integrating the physical world with the Internet via pervasive deployment of mobile and embedded computing devices. The ability to view, search and interact with the physical world will enhance our lives in numerous ways. The result is a set of evolving "wireless ecosystems" that are weaving wireless information into the fabric of human life and society (see Figure). These pervasive ecosystems will comprise tens of billions of wireless devices connected wirelessly to the global network, a scale that is two orders of magnitude larger than today's Internet and presents new challenges related to enabling technologies, system architecture and human-centric design.



Thus, the need is for an engineered communication and computing system that is unique in that it is intricately tied to supporting various human-centered applications while at the same time appearing to be seamless and invisible to end-users. In terms of key enabling technologies, the communications/networking challenge is that of designing hierarchical, distributed, decentralized and adaptive protocols for dense wireless networks and integrating efficiently with the future Internet as a whole. The computational challenge calls for operating systems, socket and programming language abstractions and analyses suitable for dealing with the physical world in a much more robust way than today's systems. In addition to these challenges, security and

privacy considerations take on added importance, given the very personal and ubiquitous nature of the technology and its uses. Social, perceptual and cognitive sciences are, of course, central to the study of applications and how end-users would interact with pervasive systems.

Understanding and evaluating this rich set of possibilities represents an important research opportunity, and one in which WINLAB is particularly well-positioned to take a leading role. Our overall goal over a 10 year period is to become a major factor in government- and industry-supported research and development in this important new area. To begin this process, we will bring together a diverse and talented multidisciplinary team that will work closely to establish common research methodologies and tangible outputs that impart benefits to the society of the future. Integrating fundamental research with experimentation on a host of testbeds (such as ORBIT, KANSEI, VINI, V2V), the research output of the team will include key technology advances in spectrum coexistence algorithms, cognitive radios, self-organizing adaptive wireless networks, future Internet protocols for pervasive networks, novel programming and computing models, security/privacy protocols, new human-centric interfaces for ambient networks, along with system prototyping and application development. The research agenda will be organized into the following thrust areas:

- **Smart radios and coexistence -** cognitive radio technology, spectrum sharing algorithms, radio resource and interference management
- **Future pervasive networking –** network architectures, adaptive protocols, location and content aware multihop routing, integration with the future Internet
- **Computing models and software –** real-time control, new programming and computing models, socket programming for physical world interactions
- **Security and privacy –** algorithms for network security, location privacy and trust
- **Applications and Human-centric design –** application design and control, learning algorithms, human-centric interfaces, social informatics

To drive top-down system design and to validate developed architectures and technologies, the team will pursue three near-term application areas that share several common attributes and challenges associated with wireless ecosystems. Yet they also present distinct and unique opportunities for solving critical societal problems of great importance:

- Inter and intra vehicular communications for public safety
- Information management in emergency healthcare applications
- Networked robots for disaster relief and recovery

To speed up innovation and the path to commercialization of the relevant technologies, we will work with our industry partners in the early as well as translational phases of research and development. The initial sets of target applications we have chosen above provides an immediate and important but small window into the endless possibilities such engineered wireless ecosystems present. We believe that these pervasive wireless ecosystems will become an integral part of our world in the near-future and beyond. In fact enabling such a pervasive communication and computing infrastructure will only further drive this revolution to fruition.