

Uncertain, dynamic, out of control ?

Coordination and Cooperation in Next Generation Systems

Paul Havinga
University of Twente

Marc Weiser's vision

- Desktop computer replaced with embedded computing in physical objects
- Small and invisible
- Enhance original functionality of physical objects
- People would do their work assisted by computer technology, but without having to focus on the computers

Emerging Application Paradigms

- Ubiquitous Computing
- Smart Spaces
- Sensor Networks (e.g. EYES)
- Active Badges and Tags
- Home Networking, e-everything
- Information Appliances
- Wearables
- ...

Status Quo


- Ubiquitous Computing
 - Marc Weiser's vision, 1988: a dream
 - 2003: a dream made possible: enabling technologies
 - low cost embedded devices
 - wireless networking
 - Low cost, small physical I/O
- Current ubiquitous computing research
 - building prototypes
 - exploring design opportunities

Deeply Networked Systems

- "Everything" is networked
 - Even very small things like sensors and actuators
 - Explosion in the number of connected end devices
- In-network processing
 - Protocol stack plus some ability to execute mobile code in network end devices
 - Decentralized control
 - Services executing inside the network


Challenges (1) diversity, dynamics, and resources

- Many (many!) devices
 - Small
 - Very limited resources (processing, memory, wireless communication, ..)
 - In particular: very limited energy!
 - Need radical new protocols across the whole system!
 - Very heterogeneous types of devices
 - Heterogeneous wireless networks
 - Interoperability
 - competition
- Dynamic
 - Applications
 - (physical) environment




Challenges (2) How to control?

- Too many to operate by the user
 - Installation
 - Configuration
 - Maintenance
 - Discovery
 - Reconfiguration
- Protocols need to be
 - Autonomous, distributed, localized, light-weight




Challenges (3) Competition

- Competition in a dynamic heterogeneous environment
 - Diverse applications
 - Diverse platforms
 - Competing for resources
 - Frequency
 - Bandwidth
 - Processing power
- Egoism, altruism, or collaboration




Challenges (4) Dependability

- Devices fail
 - Since there are so many, there will always be failures!
- Malicious behavior
- Many competing devices
- Open environment
 - New technologies
 - new applications
 - Standards? Probably too many!!




Challenges (5) Abstractions

- Abstractions
 - Many heterogeneous sources of information
 - How to address devices and resources?
 - How to identify availability?
 - Service discovery
 - Cannot afford
 - a centralized approach
 - A layered abstraction



Opportunities

- Many, though distributed, resources
 - Use whatever is available
 - Choose the best fitted
 - Devices are allowed to fail
- Collaboration
 - To increase quality
 - To increase robustness
 - To enhance energy efficiency



What do we need?

- An **architecture and framework**
- Research that
 - Is system wide
 - Is multi-disciplinary
 - Is aware of resource limitations
 - Exploits the opportunities



What we cannot afford

- For tiny distributed devices
 - Use 'standard' middleware solutions
 - Standard layered network protocols
 - Use centralized mechanisms
 - To trust
 - The environment
 - Others
 - Applications
 - Rely on technology to solve resource problems
 - In particular ENERGY!