Looking ahead in pervasive computing: Challenges and opportunities in the era of cyber–physical convergence

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Cyber-physical world

- Information flows from the physical to the cyber world and vice-versa
- Humans in the center of the convergence
  - Characterized by the large number of mobile devices
Cyber world

- Data
- Policies
- Communication networks

Pervasive apps & services

Data gathering through sensors
Physical world adaptation through actuators
CPW interactions mediated through social networks

Physical world
Pervasive computing

- Computing existing everywhere
- A growing trend of embedding computational capabilities into everyday objects
- Microprocessors
Autonomic behavior of the cyber world infrastructure

- A research challenge related to the need for
  - Autonomic
  - Self-managing
  - Self-adaptive

- Both at infrastructure and service level

- Paper concludes that current proposals suffer limitations
Autonomic behavior of the cyber world infrastructure

- Proposals have limitations
- Adding onto existing frameworks increases complexity
- Fully decentralized, inspired by nature
  - Most proposals focused on specific algorithms, not tackling issue of autonomic self-adaptation
Autonomic behavior of the cyber world infrastructure

Challenges:

- Comprehensive situation-awareness
- Top-down vs. bottom-up
- The power of the masses
- Decentralized control
- Diversity and evolvability
- Mechanisms design
Studying the physical world from the cyber world

- Active research subject
- Tracking people
- Collective human behavior
- Mass observation, can be used in urban planning
Research community will have to investigate following:

- Address issues with personal data use and privacy protection
- Develop techniques for efficient analysis if large data sets
- Explore a wider variety of dynamics within realistic situations
Opportunistic Networking and Computing

- **Opportunistic networking**
  - Fluid networking environment
  - Opportunistic contacts between pair of devices
  - Uses mobility to enhance data distribution
  - User-centric approach

- **Opportunistic computing**
  - Exploits appropriate, but opportunistically available resources
  - Exploit resources on another users device
Five grand challenges

- Interplay between human social interactions and ONC
- Scalable solutions with large number of devices and shared content
- Utilization of resources
- Motivating users to participate in packet forwarding
- Efficient management of information flow
Information Management

- Scalability
- Complexity
- Flexibility
- Reproducibility
Security

Two challenges

● Attestation and code update for embedded devices and networks
  ○ How can we be sure that pervasive devices run the intended software and nothing else?
  ○ Secure Hardware
  ○ Pure Software
  ○ Hybrids
● Usable and secure configuration of pervasive devices