Networking Cyber-physical Applications in a Data-centric World

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Computers weaving “themselves into the fabric of everyday life until they are undistinguishable from it.” (M. Weiser 1991)

- **CPS**
  - IoT
  - Pervasive
  - Ambient computing
  - Disappearing computing
  - Ubiquitous computing
  - ...

- **Applications**
  - Personal and home
  - Smart city
  - E-health
  - Utilities
  - Mobile

- **Any-X**: thing, device, place, service...
Future Cyber-physical Applications

- Intelligent, embedded to be responsive and dynamic in the presence of people
  - OS1 in movie “her”
  - Context-aware

- July issue of “Science”: synthetic therapist

Networking + Big Data Analytics + AI

ICCCN 2015 Panel
Smart City: Geo-Social Collaborations

- Mapping: geo-space (physical) & social space (logical)
- Differentiated resource provisioning in smart city

- Power of masses: predicting mobile data
  - Semantic place, next place, demographic attribute...
Social Feature-Based (Wu & Wang 2013)

- Mobile & unstructured contact space (M-space)
- Static & structured feature space (F-space)

- Each individual with a social feature profile \( \{F_1, F_2, \ldots\} \)
- Searching on a n-D hypercube using INFOCOM traces

Central South University
E-health: fetal health monitoring

- Support both in-home and in-hospital monitoring

In home
- Long range wireless/internet

In hospital
- Short range

PHR/Hospital DB
US Ignite: Surveillance System

- Develop WiMAX enabled public safety surveillance system for university campus police

Key features

- Use 3D cameras (e.g. Kinect) for monitoring
- Supercluster backend for video surveillance
- QoS-based on wireless performance feedback
- Secure data transmission and data sharing
Rate Adaptation

- QoS challenges

Adjust video quality

On-board processing

Adjust wireless quality

Remote processing
Future Challenge

- Future Networking
  - IoT
  - 5G and SDN
  - Content delivery networks
  - Wireless + DTN
  - DCN

- Social Networks
  - Geo-social collaboration
  - Trust management
  - Security and privacy

- Drive-To-Zero
  - Latency hiding

- Killer Apps
  - UI: wearable computing

- New Technology
  - Communication beyond wireless
  - Dynamic spectrum sharing
Future IoT

- By 2020
  - 2B servers/PC's, ~10B notebooks, PDA’s, smart phones, sensors, IoTs

- New requirements
  - Increased mobility; massive data; sophisticated information; limited resources

- ID and address separation
  - Single ID mapped to multiple addresses
Future Internet

- Several network standard/architectures: 5G & SDN

**5G:** An integrated set of technologies addressing a variety of use cases

**SDN:** Data plane remains with the hardware, and control plane decides where traffic will be sent
Content Delivery Networks

- Key questions
  - Content naming
  - Content location/routing
  - Content caching
  - Content delivery mechanisms

- Push, Pull, and Hybrid
  - User interests and mobile brokers
Mobile + DTN

- Mobile P2P and infostations (DTN-like): content delivery (NSF MobilityFirst project)

- Mobility as first-class: “follow-me” application
- Computation to environment binding
Mobile and Cloud Computing

- Cloud computing: software, platform, infrastructure
- **Mobile and cloud convergence**: accessibility from users

Portable: Follow us everywhere
- Rich in **context**
- Connect mobile and cloud computing

Future Internet and Distributed Cloud (FIDC): GENI and FIRE

Huge data centers
- Rich in **resources**
- Distributed storage: **CAP** (consistent, availability, partition)
Drive-To-Zero

- Qualcomm + NSF's future directions in WNs
  - 1000X: enhancement in throughput
  - 1000X: reduction in latency
  - 1000X: improvement in energy
  - 1000X: end-to-end gains

- Quality of Information (QoI)
Security and Privacy

- **Rich data**
  - Images, videos, and interactive maps
  - Metadata: geolocation, time and date stamps

- **Threats and vulnerabilities**
  - Ability to extract personal information from seemingly innocuous data
  - Expose people's hidden behavioral patterns and even intentions
Killer Apps

- Better UI
  - Wearable/implantable computing (e.g. life logging)
  - Mind-controlled (?)

- Smart energy
  - Transportation
  - Sustainability

- Health and wellness
  - Security

- Crowdsourcing

- UAV
  - Coordination
  - Safety
New Technologies

- Millimeter wave technology: Use new spectrum
- Spectrum sharing: Share the existing spectrums
  - LTE-U, Google fi
- New media for communications
  - Li Fi (visible light), ultra-sound, smoke, cloud, ...
- Powerless or low power mobile devices
  - Ambient backscatter: ambient RF from TV and energy harvesting
Message to Students

- Exciting field
- More interdisciplinary
- Focus on one subarea, and dig deep