

Networking Cyber-physical Applications in a Data-centric World

Jie Wu

Dept. of Computer and Information Sciences

Temple University

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

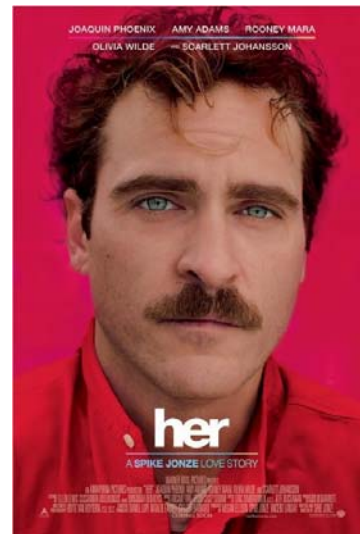
- Personal and home
- Smart city
- E-health
- Utilities
- Mobile

- Any-X: thing, device, place, service...

Future Cyber-physical Applications

- Intelligent, embedded to be responsive and dynamic in the presence of people

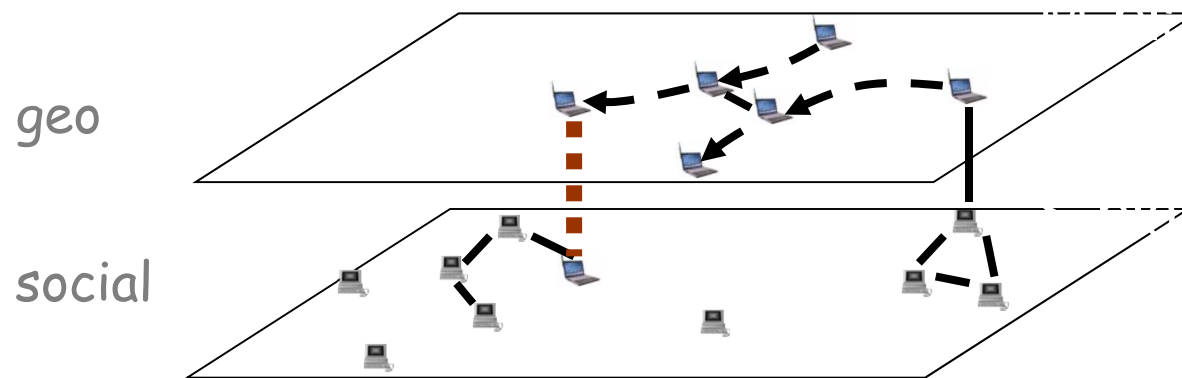
- OS1 in movie "her"
- Context-aware



- July issue of "Science": synthetic therapist
Networking + Big Data Analytics + AI

Smart City: Geo-Social Collaborations

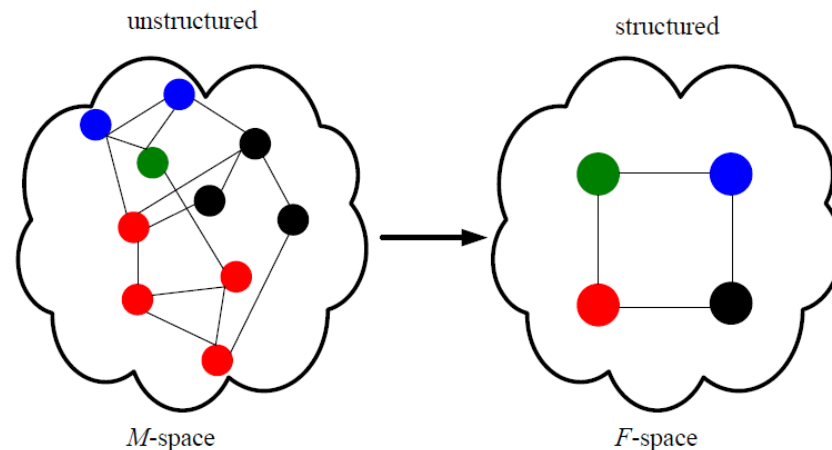
- Mapping: geo-space (physical) & social space (logical)
- Differentiated resource provisioning in smart city



- Power of masses: predicting mobile data
 - Semantic place, next place, demographic attribute...

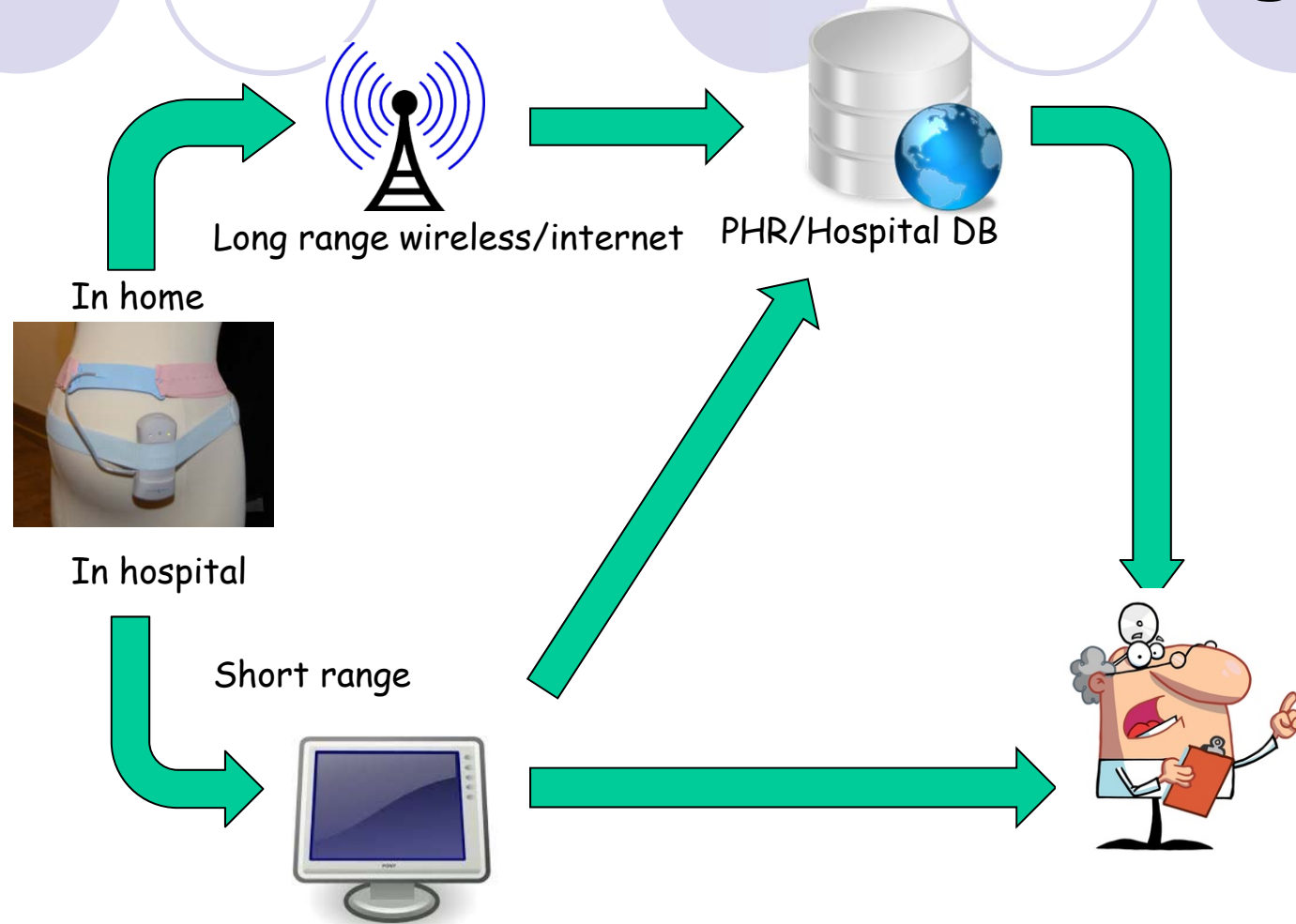
Social Feature-Based (Wu & Wang 2013)

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



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

E-health: fetal health monitoring



- Support both **in-home** and **in-hospital** monitoring

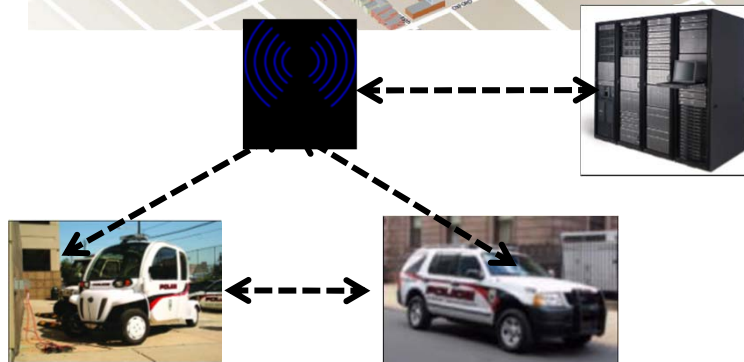
US Ignite: Surveillance System

- 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



Adjust wireless quality



On-board processing



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

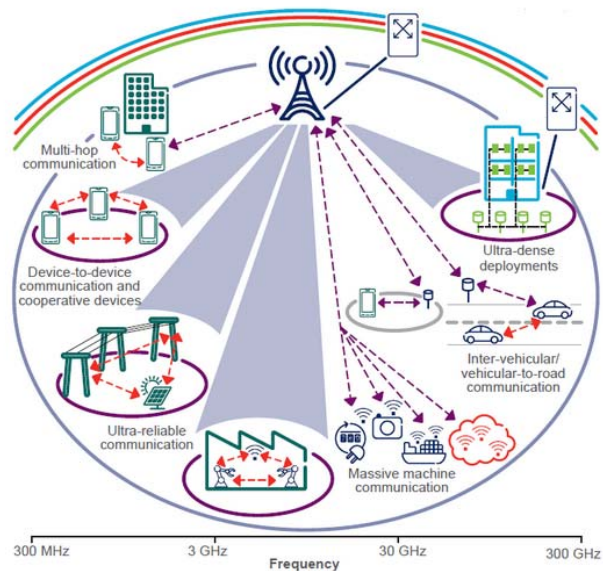
- ID and address separation

- Single ID mapped to multiple addresses

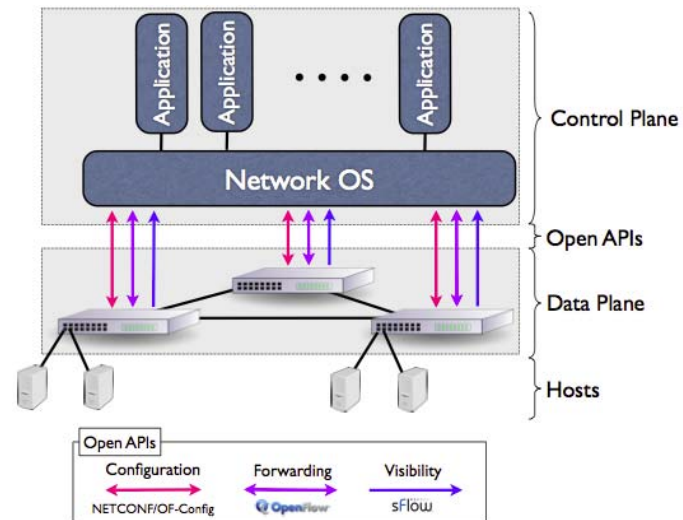
Future Internet

- Several network standard/architectures: 5G & SDN

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

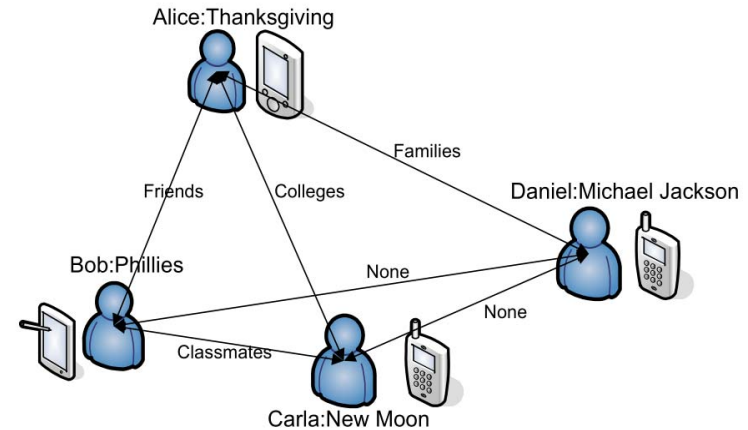


SDN: Data plane remains with the hardware, and control plane decides where traffic will be sent

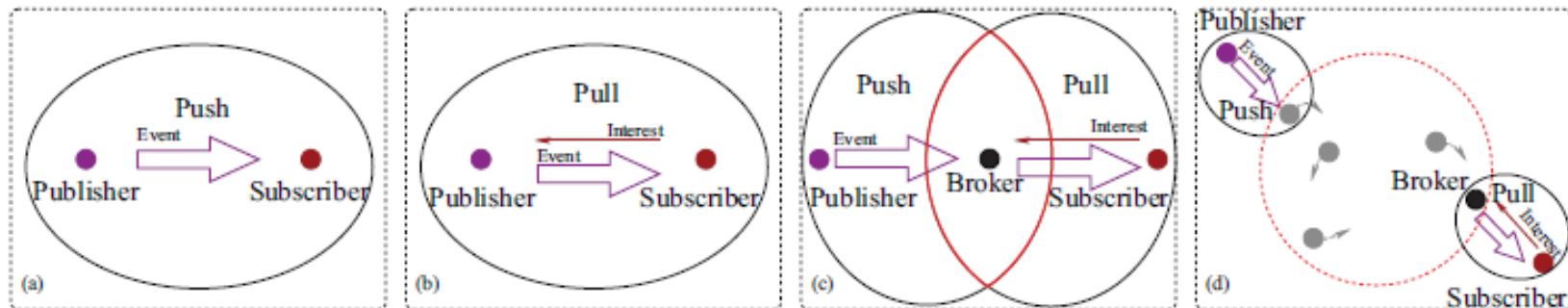


Content Delivery Networks

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

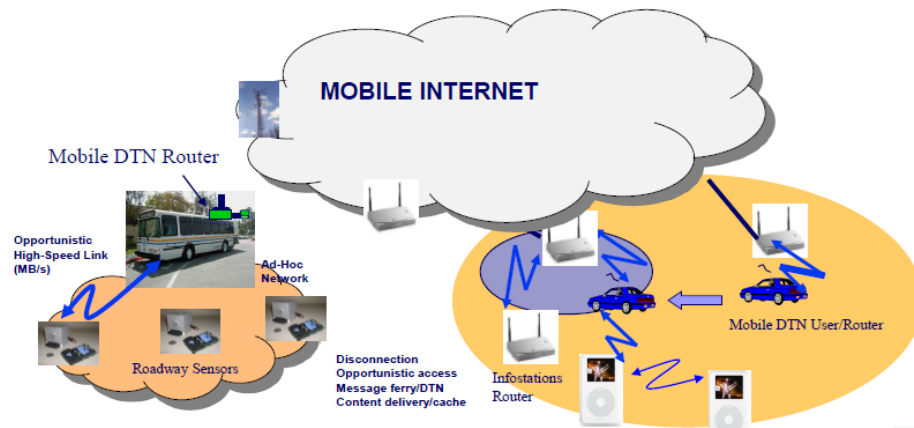


- Push, Pull, and Hybrid
 - User interests and mobile brokers



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



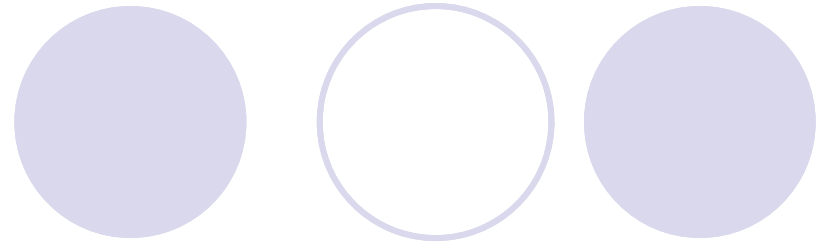
Future Internet and Distributed Cloud (FIDC): GENI and FIRE



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

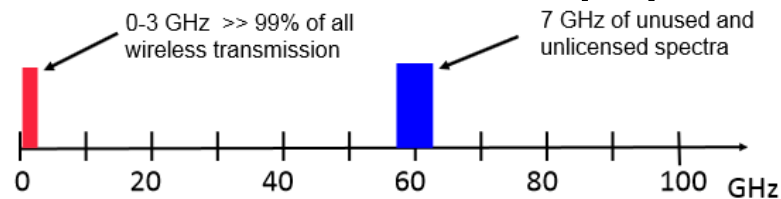
- Health and wellness
 - Security
- Crowdsourcing
- UAV
 - Coordination
 - Safety



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

