Mobile Wireless Sensor Network enables convergence of ubiquitous sensor services

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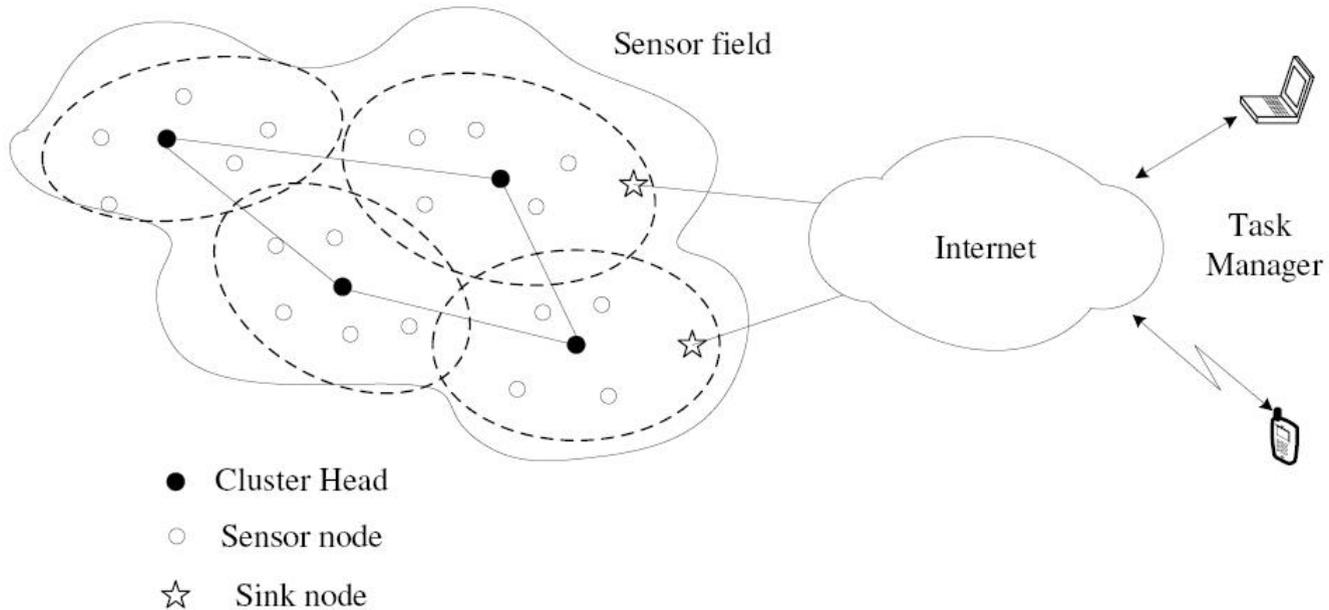NOKIA
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Outline

- Introduction to mobile enabled wireless sensor network (mWSN)
  - Backgrounds about WSN
  - Motivations towards mWSN

- Opportunities and Challenges in mWSN
  - Mobility, heterogeneity, and self-organization
  - Design principles and Tradeoffs

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Backgrounds about WSN

- Many critical issues facing science, government, and the society call for *high-fidelity* and *real-time* observations and manipulations of the physical world
  - *Embedded Networked Sensing will reveal previously unobservable phenomena*
- Multi-disciplinary technologies have enabled Wireless Sensor Network (WSN)
  - Embedded, Networked, Sensing & Control
    - Networking, Communications, Signal Processing, Databases, Embedded Systems, Controls, Optimization
    - Biology, Geology, Biochemistry, Structural Engineering, Education, Environmental Engineering
    - …
- Typical Sensing Applications
  - Periodic - *Majority of operation*
    - Data Collection, Network Maintenance
  - Triggered Events - *Infrequently occurs*
    - Detection, Notification
- From military to civil and social applications
  - Environmental/building Monitoring
  - Biosensing, Precise Agriculture
  - Education, Entertainment, Health care
  - …

WSN System Model

- Emergence of Application-Driven (not Application-Specific) Common System Model

Sensor field

Cluster Head

○ Sensor node

☆ Sink node

Internet

Task Manager

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WSN Services, Tools, and Advance

- Reusable, Modular, Flexible, Well-characterized Services & Tools:
    - MAC, Topology Management, Routing, Transport
    - Time synchronization, Localization
    - In-network Processing: Sample Collection, Triggering, Tasking, Fault Tolerance
    - Programming abstractions, Network querying
    - Simulation/Emulation, Self-test and Debugging tools
    - Visualization/Management tools
    - Data cleaning, modeling, fusion, interpretation, inference
    - …
- Experience with large and long-term deployments
    - Experimental system
    - Industry automation
- *Mobility* and *Heterogeneity* are being re-considered
    - Connectivity and Scalability
    - Cluster and Overlay

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Motivations for mobile WSN

- Mobile phone has been the most popular computing platform continually carried by people
- Diverse RFID (Radio Frequency Identification) tags are believed to be massively deployed in daily life
  - RFID and other tags as lowest layer in sensor network
- To cope with the increasing demand for ubiquitous computing and ambient intelligence, it is becoming imperious to
  - design heterogeneous multi-hop mobile WSNs in order for mobile users to harvest information anywhere and at any time
- As the *agents* of mobile users, mobile phones will by nature be qualified for the tasks of gathering info from surrounding RFID tags and sensors
- Interactions between user *profiles* and wireless *context* will facilitate better mobile experiences and create new opportunities for future lives

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mWSN Architecture

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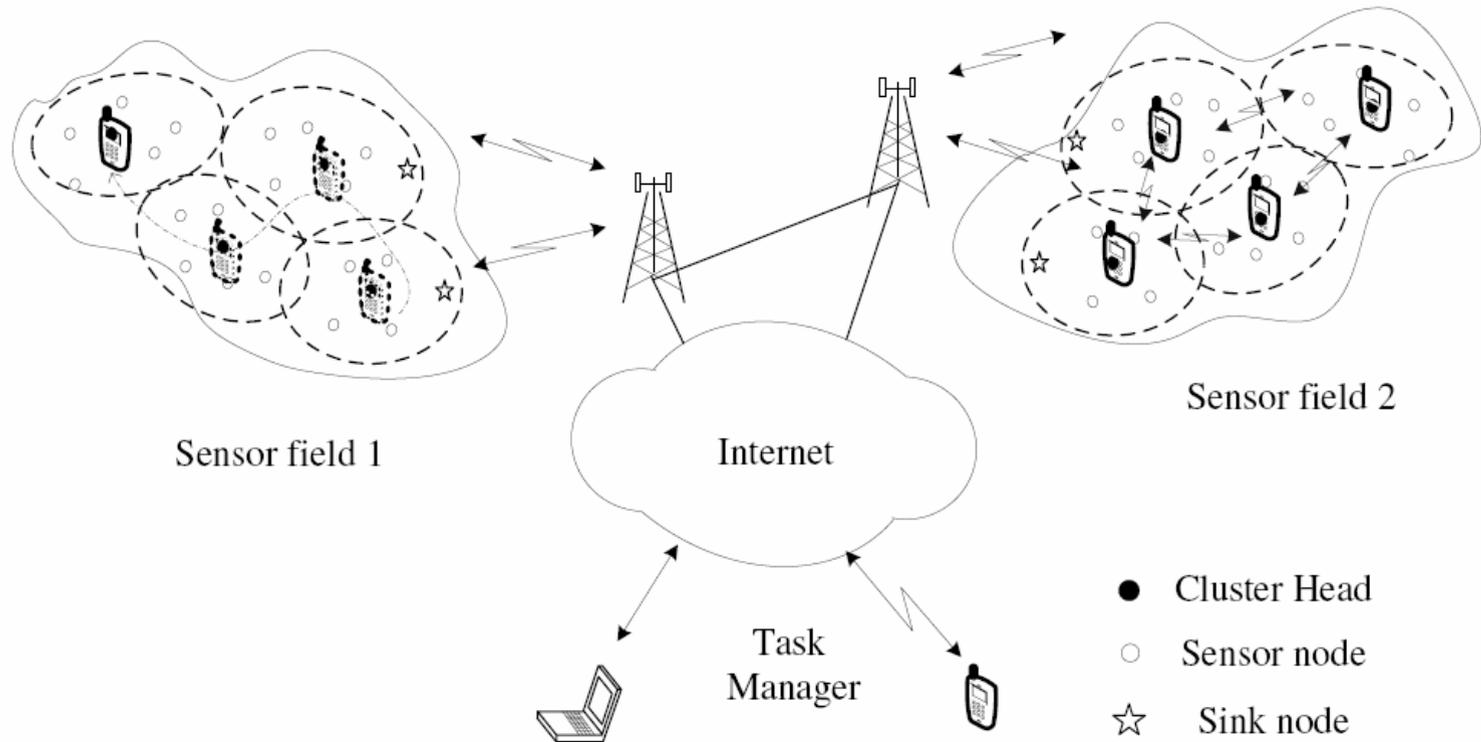
Heterogeneity and Mobility

- **Heterogeneity:** radio, computing, energy, type, …
  - **Radio link** heterogeneity leads to hierarchy/overlay, more scalable
  - **Energy** heterogeneity suggests routing optimization, not shortest-path-first
  - **Computing** heterogeneity partitions whole network to different roles
  - **Actor/Actuator** nodes with decision unit
    - Provide greater functionality than sensor nodes: make decisions and perform actions
    - Example: WSAN – feedback closed loop
  - *Mobile phones have multiple radios, and will become powerful computing devices besides communication devices*

- **Mobility:** information mining on-the-fly
  - One mobile sink equals virtually multiple sinks
    - Example: Networked Info-Mechanical Systems (NIMS)
  - Reduce path length, energy consumption, energy dissipation non-uniformity
  - Enhance coverage, connectivity, and relocability
  - Realize adaptive resource provision and fidelity-driven sampling
  - *Mobile phones can gather and process information on-the-fly, realizing interactions with ambient intelligence*

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Self-Configuration

- Self-Organization behavior can be observed in
  - Chemistry, Physics, Economy, Biology, Social Sciences, etc
  - IP networking, ALOHA protocol, TCP congestion control, etc
- Self-Organization is an inter-disciplinary and heterogeneous field, with merits such as *Adaptive, flexible, failure-robust, scalable*
  - SOS Related Definition
    - *Organized* – a <u>system</u> has a certain <u>structure</u> and <u>functionality</u>
    - *Self-organized* – a system is organized without any external or central dedicated control entity
- The main current scientific theory related to self-organization is *Complexity Theory*, which states:
  - Critically interacting components self-organize to form potentially evolving structures exhibiting a hierarchy of emergent system properties
- *mWSN may be applied in Universal Plug and Play (UPnP), Pervasive Networking, Emotional Computing, etc*

Advantages and features of mWSN

- Multi-Radio heterogeneity in wireless networks can be leveraged to construct small world networks

- Introduction of mobile sink can reduce path length and energy dissipation non-uniformity

- Sensor mobility can be exploited to compensate for the lack of sensors or sensor failures and improve network coverage

- Emerging of Multi-Radio mobile terminals enables the possibility of combining the role of Sink and Sensor

- Classical definitions and scenarios of WSN may be modified for potential mobile applications

Summary

- Emerging of Multi-Radio mobile terminals builds gateway for people to access any WSN services

- mWSN enables convergence of ubiquitous sensor services

- Multi-Radio heterogeneity in wireless networks can be leveraged to connect small world networks

- mWSN enables innovative ubiquitous applications

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Thank you

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