Cloud Centric Participatory Mobile Sensor Network for Smart City/Nation

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Outline

- The Smart City and Smart Nation

- Sensor Networks in Smart City/Nation

- Mobile Sensor Networks(MSN) versus Fixed Sensor Networks

- Computing in MSN

- Participatory MSN

- Research Challenges in Participatory MSN

- Summary and conclusions

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Singapore's Smart Nation Vision

"A nation where people live meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all."

- Prime Minister of Singapore,
- Mr Lee Hsien Loong

Singapore's Smart Nation Vision

Smart Nation
S I N G A P O R E
Many Smart Ideas · One Smart Nation

- Improve the quality of life for individuals, and business opportunities for enterprises
  - ❖ An anticipatory Government that can better serve the citizens and better able to use technology to enhance public services
  - ❖ Empowering citizens to be able to be more participatory in engaging government, as well as businesses, to make more **informed decisions** and **meaningful choices** in their daily living

The Smart Nation Platform

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Confidential
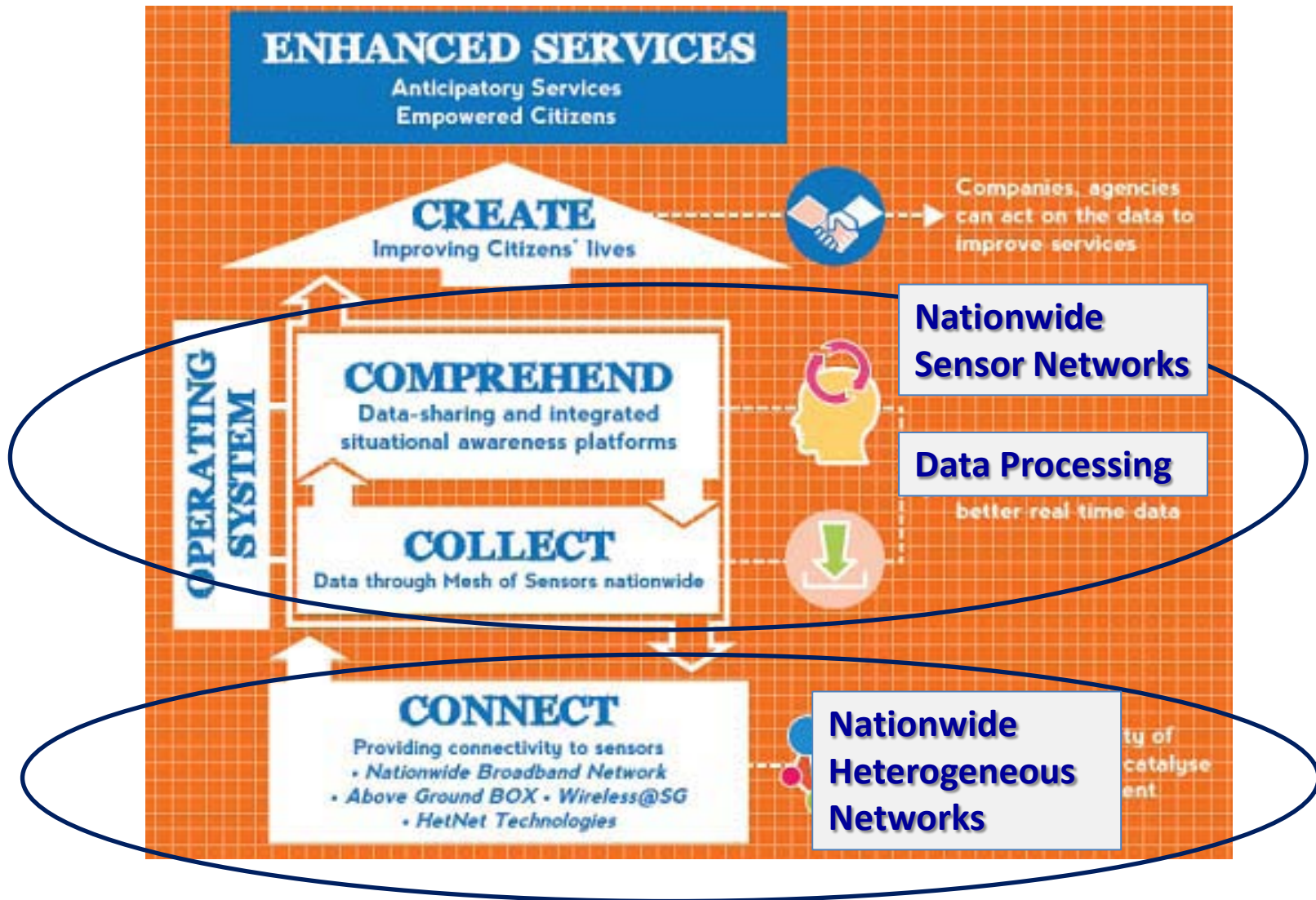
Nation-wide/City-wide Sensor Networks

Dense and fixed deployment of sensors everywhere??

Or limited number of sensors on the move?

Nation-wide/City-wide Sensor Networks

Dense and fixed deployment of sensors
- **Large number of sensors and gateways**
  - **Power supply**
  - **Camouflage into the environment**
  - **…**

Or limited number of sensors on the move?

Sensors on the Move

- Multiple sensors embedded on vehicles
  - Noise
  - Pollution
  - Temperature
  - …
- On-vehicle gateway aggregating information from both on-vehicle and off-vehicle sensors
- Vehicles on the move, hence guaranteed coverage with sufficient number of vehicles
- Location stamp enabled by vehicle-integrated GPS
- The total number of sensors and gateways significantly reduced

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Sensors on the Move

- Timely information transfer to cloud with vehicle-to-vehicle and vehicle-to-infrastructure communications

- More can be possible – vehicle itself as a sensor
  - Congestion information

- Inherent adaptive mechanism
  - During busy hours, the many vehicles on the road provide detailed coverage of the traffic conditions both in space/area and in time scale
  - During the less busy hours, the much fewer vehicles on the road provide more sparse sampling of the traffic conditions
    - acceptable for less demanding coverage and updating frequency

  good tradeoff between accuracy, efficiency, as well as quality of experience to road users

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A Closer Look at the Two Architectures

Fixed Wireless Sensor Networks

- **Large number** of sensors for fine-grained data acquisition
- **Large number** of gateways for coverage
- (Usually) **low duty cycles** of data transmission
  - Sleep mode and duty-cycle management
- Challenging to
  - Arrange suitable **locations**
  - **Power** the sensors and gateways
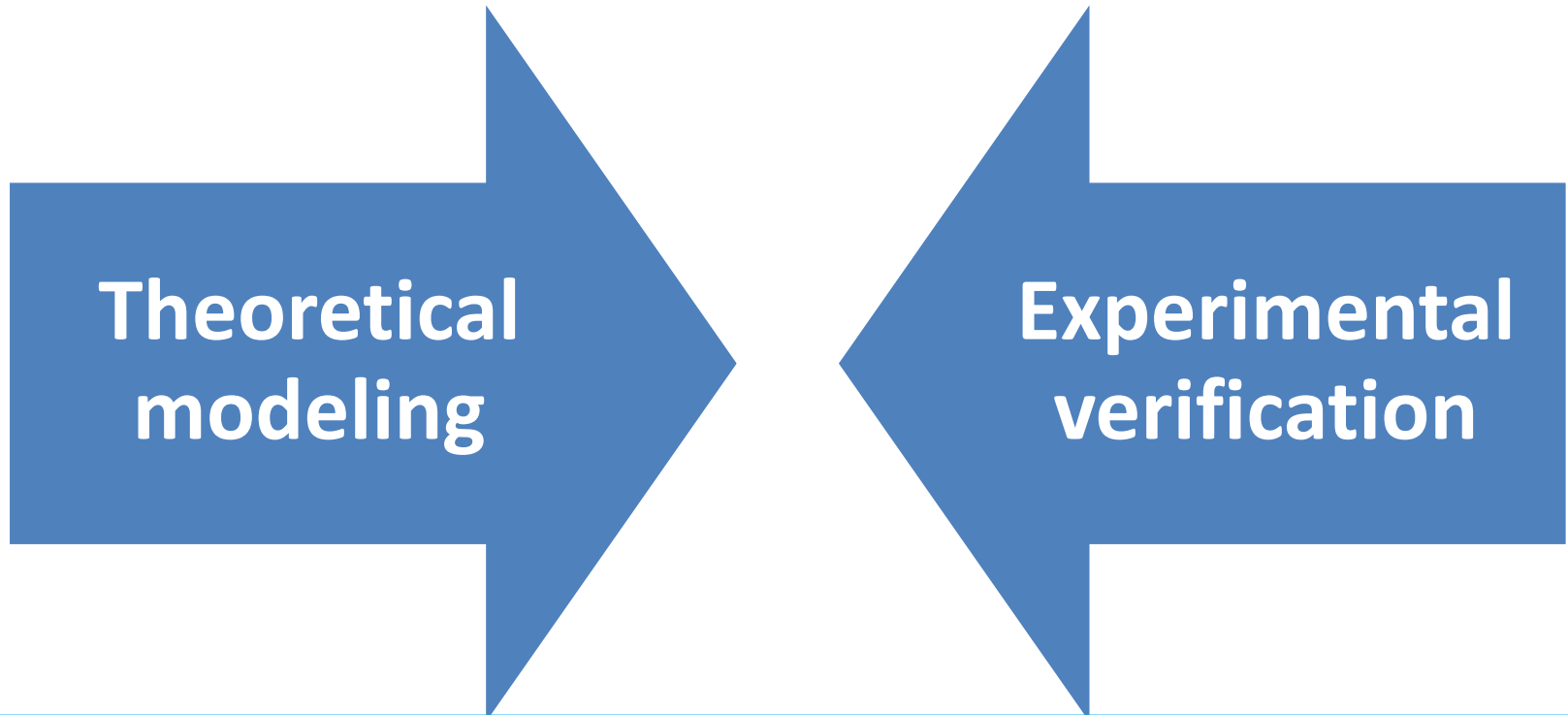 - Camouflage the sensors/gateways into the environment

Mobile Wireless Sensor Networks

- **Much less number** of sensors by taking advantage of mobility
- **On-vehicle gateway** for data aggregation and processing
  - Both on-vehicle and off-vehicle sensors
- Vehicle as the power source
- **Vehicular communication network** for transmitting the sensing data
- **Enhanced resilience** to errors with inherent nature of redundancy and repetition

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Design Challenges and Possible Mitigation

- Highly dynamic network topology
  - Mobility pattern information may be used to guarantee
    - sufficient coverage
    - Timely update of information
  - Joint engagement of vehicles with
    - regular routes and mobility pattern, e.g., buses
    - Random pattern, e.g., taxis
- Computational structure
  - Cooperative versus non-cooperative sensing and compression
  - Edge computing versus cloud computing
  - Tradeoff between compute and communicate
- Incentive schemes for vehicle owners' participation
- Privacy and security protection for vehicle owners

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Proposed Approach

Theoretical modeling

Experimental verification

- Coverage versus number of vehicles versus updating frequency
  - Fixed & random routes
- Computational structure
  - Edge computing versus cloud computing versus hybrid of both
- Participation versus privacy protection
  - Incentive mechanism
  - Privacy preservation
- Impact of mobility

Summary and Conclusions

- Wireless sensor network is an essential part of smart city, smart nation

- Billions of devices to be connected to internet

- A mobile sensor network is proposed by leveraging connected vehicles

  - Less sensors

  - Less gateways

  - Better resilience

  - Guaranteed coverage

- Research and design challenges need to be overcome for successful implementation and deployment

Thank you!

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