Enhanced Routing for Intermittently Connected Mobile Vehicular Network

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Outline

1. **Why to do**

Current situation of communication tech. in ITS

- **Not ubiquitous & Not peer to peer & Not on site**
- **Vehicular communication**

2. **What to do**

Ideas

- **Provide useful travel information**
- **Keep informed everywhere**

3. **How to do**

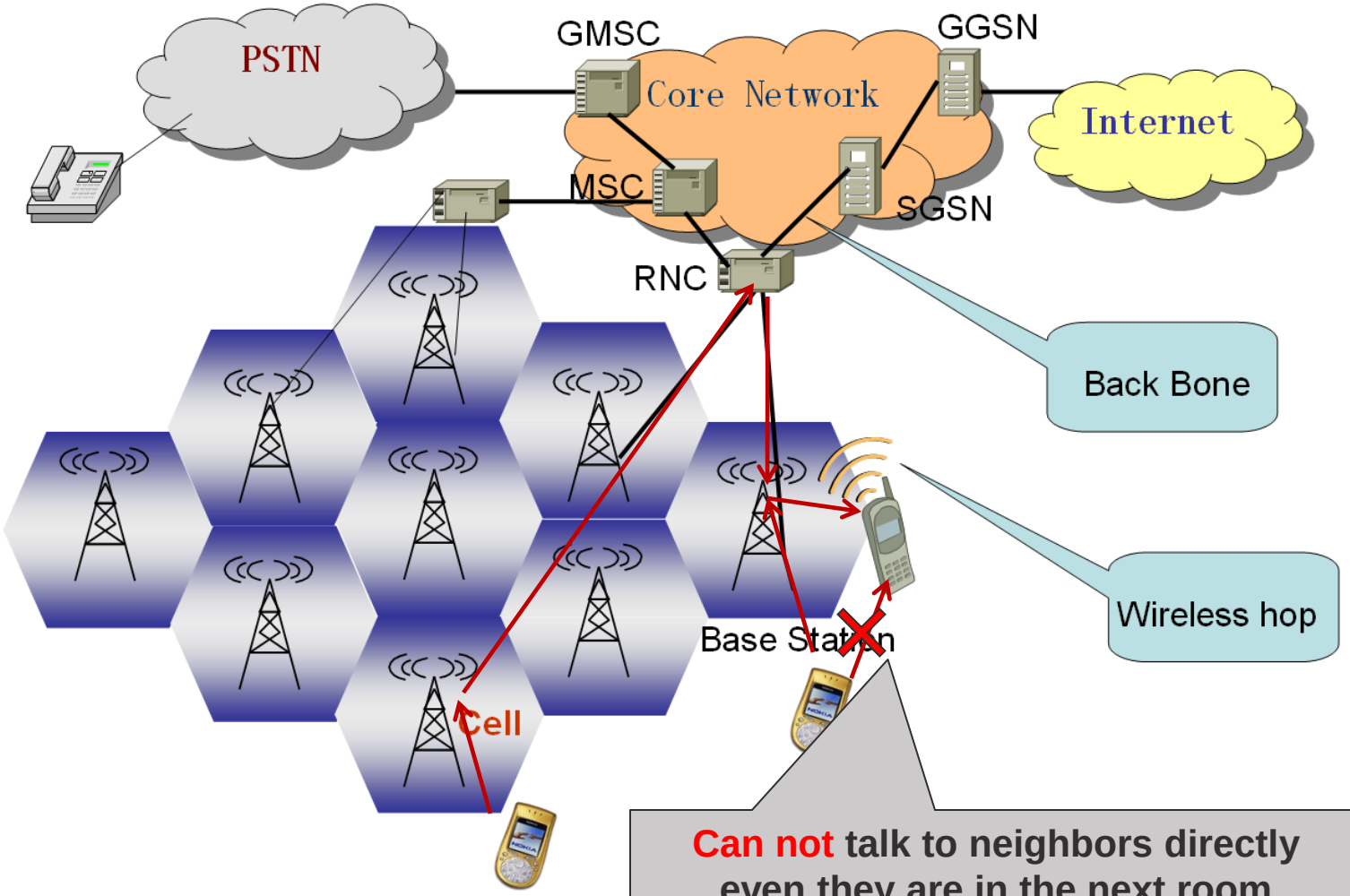
Main works

- **Mobile relay network for travel information**
- **Vivid demonstration of shopping and traveling**

Why to do

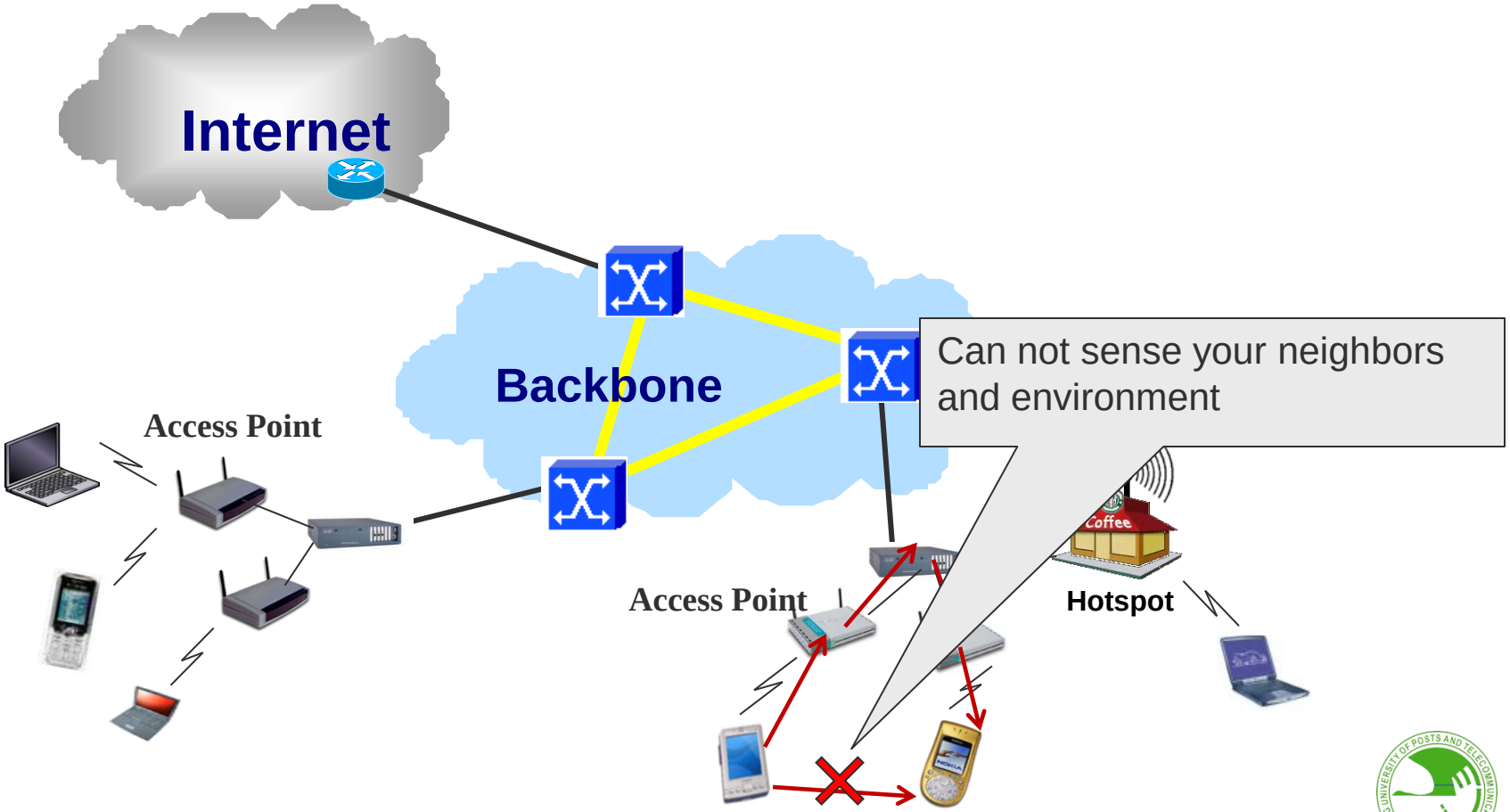
- Endeavor to achieve ubiquitous computing
  - Interact with the environment
  - Internet of Things IOT
- Traditional communication are not ubiquitous
  - Lack of information on moving
  - Not peer to peer
- Other restrictions
  - Fixed backbone — Vulnerable, expensive
  - Blind spots — Partially covered
  - Isolated area — Partially covered
  - Mobility — Frequently disconnected
  - Energy — Frequently disconnected
  - Capacity — Frequently disconnected

Limitations of Cellular Networks



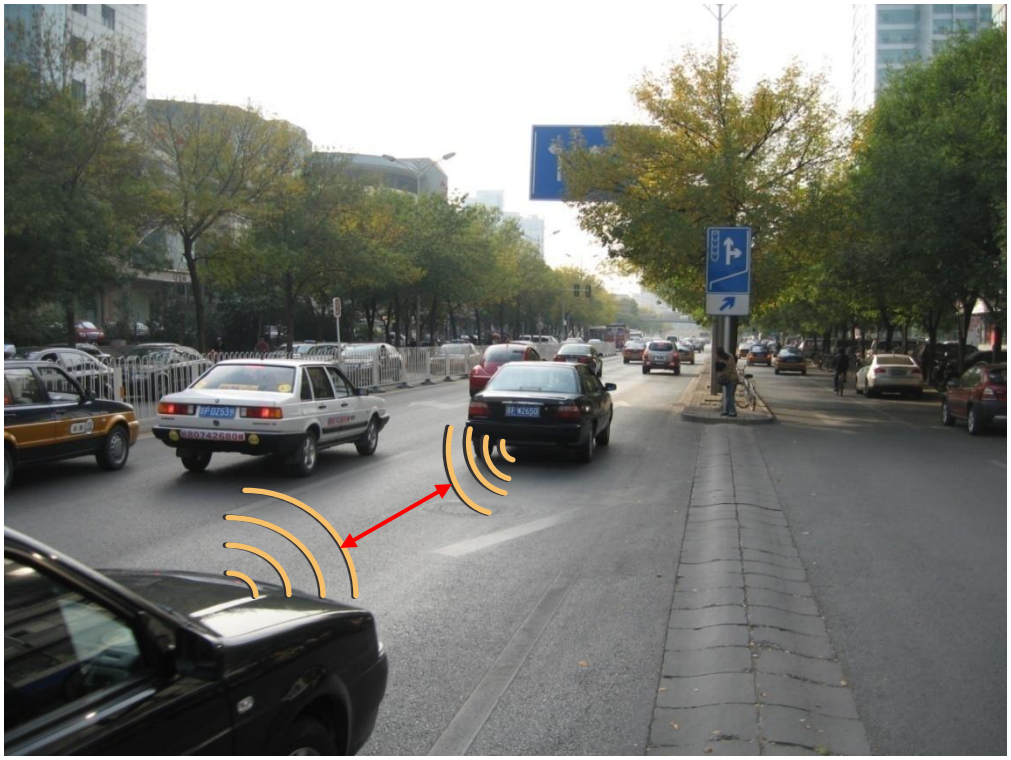
Limitations of WLAN

- Wired backbone + Wireless last hop



Vehicle-to-Vehicle communication

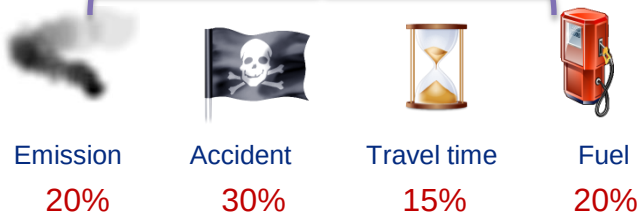
- Vehicle-to-Vehicle communication (V2V)
  - Peer to peer, interaction
  - Instant and random contact
  - None line of sight (NLOS)



- Navigation
- Ask local driver for direction
- Traffic report
- Accident prevention and response

The effect on our life

- Insufficient information access on moving
  - Missing the favorite shop
  - Make trip for nothing
  - Wasted trip
  - Traffic jam

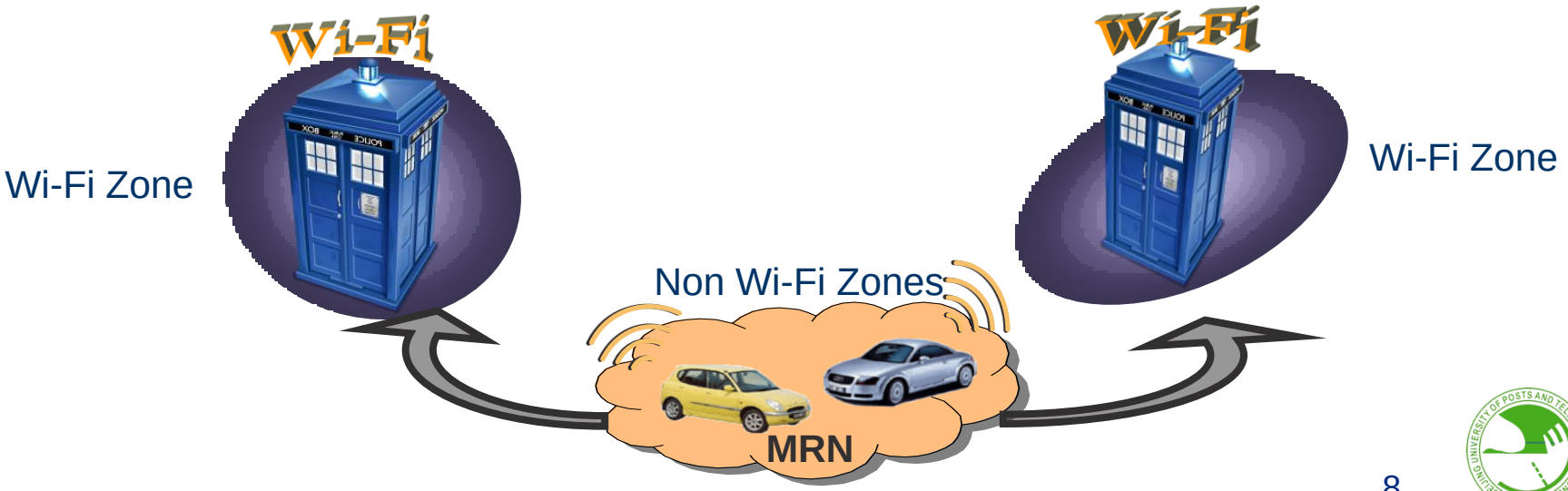


- Limitation of current ways
  - By eyes, none line of sight
  - By keyboard, inconvenient
  - By SMS, garbage information
  - By Phone call, ask what, ask whom?

Not peer to peer and not ubiquitous

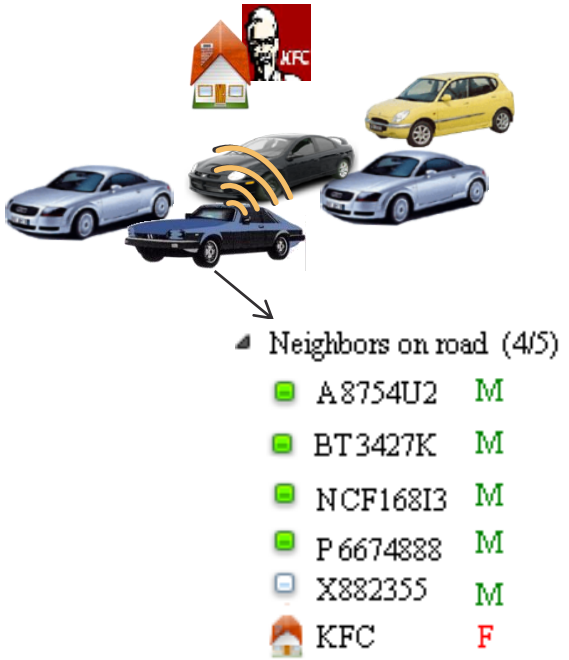
What to do

- Vehicular Ad hoc Networks
  - Let vehicles and shops carry message for us
    - Shops : fixed sites
    - Vehicles : mobile sites
- Mobile Relay Network (MRN)
  - Let cars sense the neighbor cars and shops
  - Let cars bridge the gaps



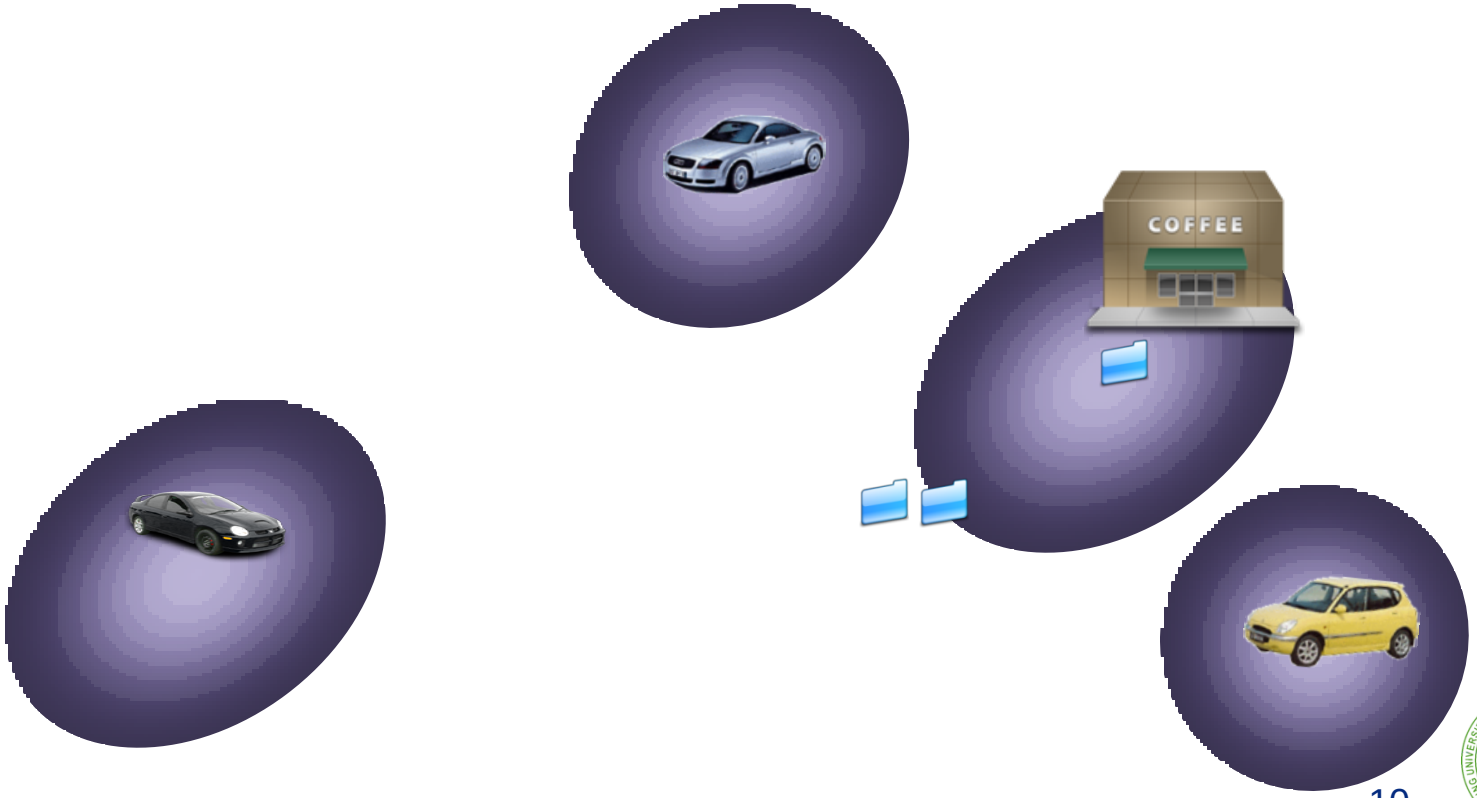
Messages from neighbors on road

- Sense the neighbor cars
- Sense the passing by shops
- Exchange messages
  - Traffic conditions
  - Navigation
  - Shopping information

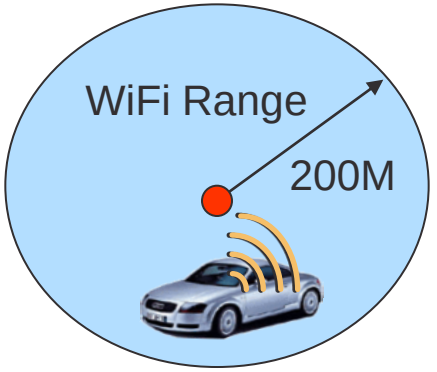


Mobile Relay

- Communication among cars in the *vicinity*
  - To neighbors: Message pushing on encounter
  - To cars far away: Via multi-hop relay

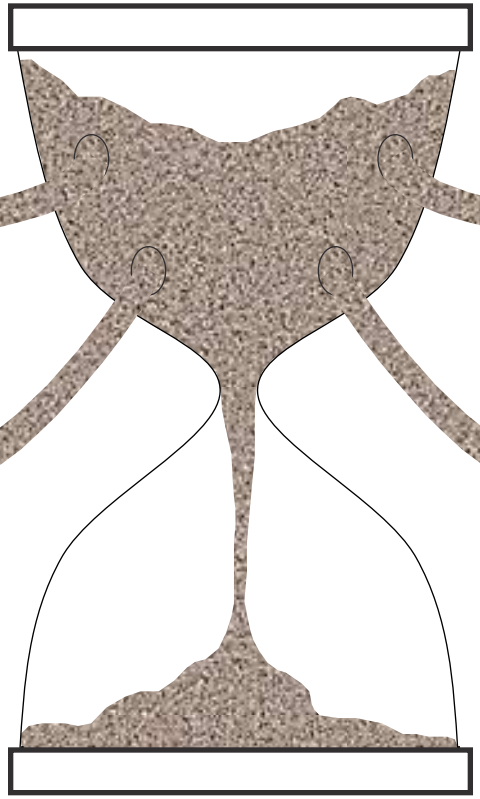


Challenges



Low duty cycle operation

Mobility



Short life of path

Disconnection of network

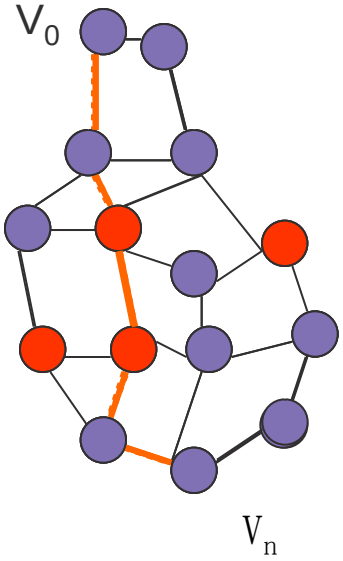
Large delay

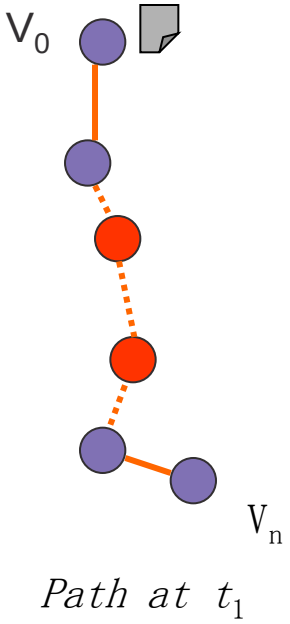
Traditional network protocol would **fail !**

How to do

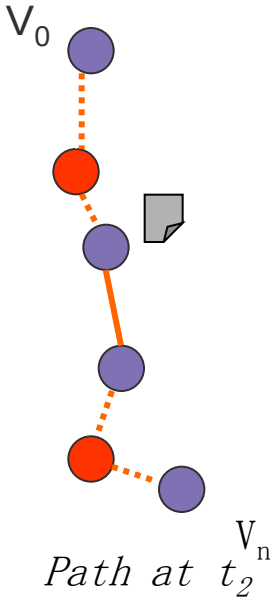
1. New routing protocol with “Store-Carry-and-Forward”
2. Group division for clustering
3. Performance evaluation

Topology of MRN network





Path at t_1

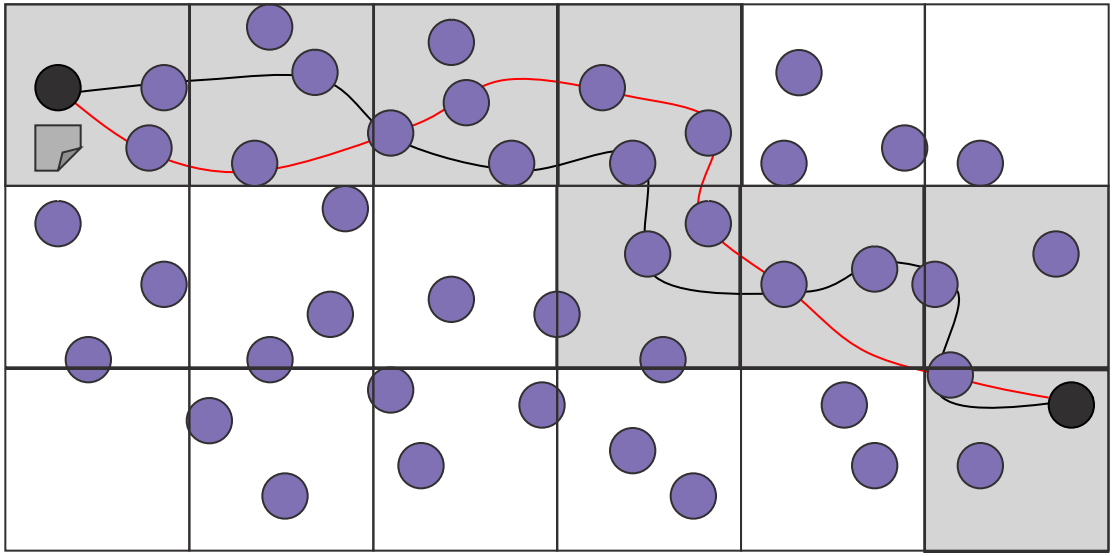


Path at t_2

Path is intermittently connected
or partially connected

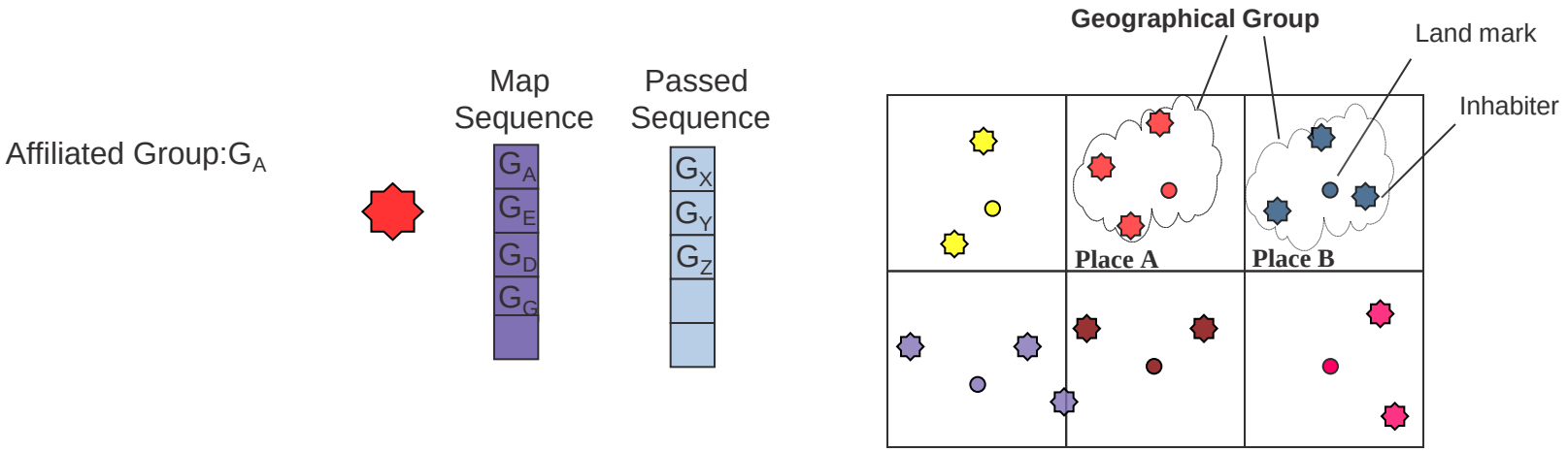
Routing

- Group sequence indicates the direction
  - Avoid the flooding of message copies
  - Increase the probability of success

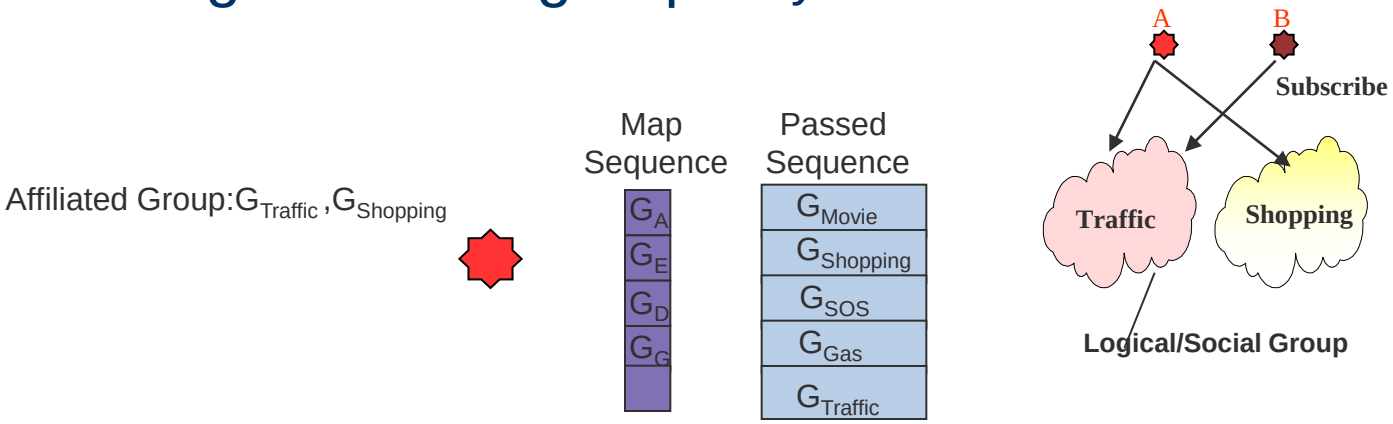


Group Definition

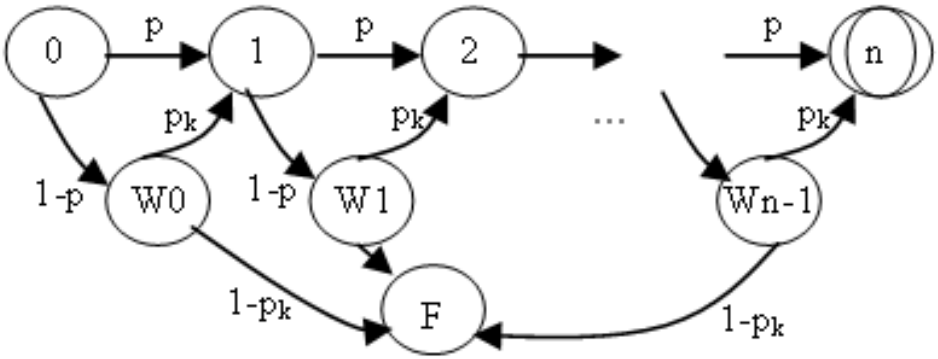
- Geographical group--by location or inhabitation



- Logical/social group --by interests or service



CTMC Evaluation Model

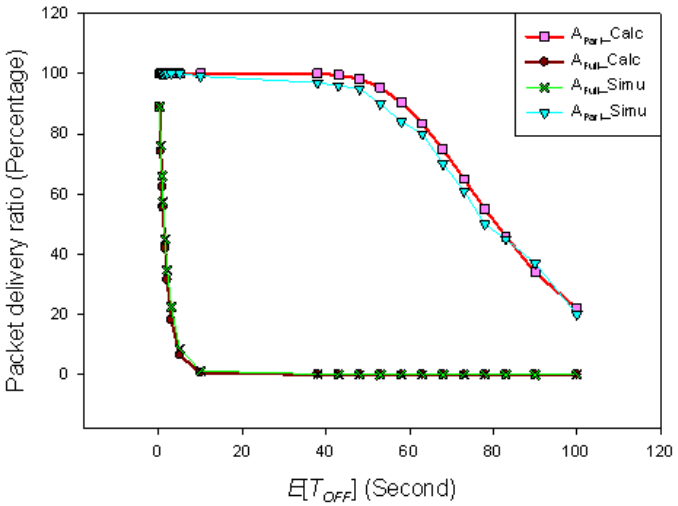


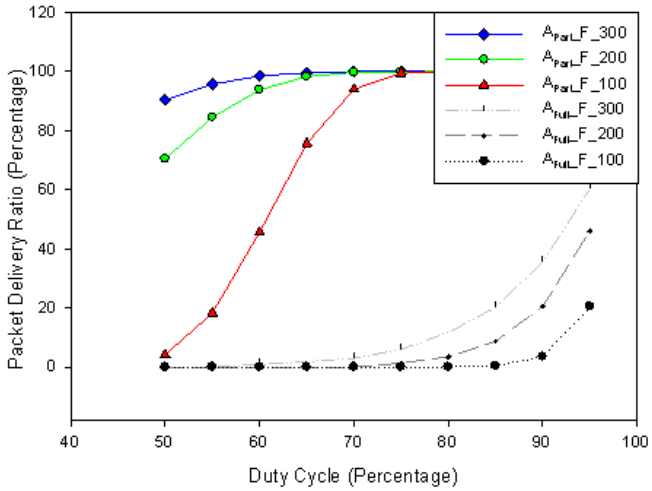
$$A_{Part} = \Pr(PP) = \sum_{i=0}^{n} \Pr(ON_i)\Pr(PP|ON_i)$$

$$= \sum_{i=0}^{n} \left[C_n^i \frac{\rho^i}{(1+\rho)^n} \left(1 - \sum_{k=0}^{n-i-1} \frac{(T\mu)^k}{k! e^{T\mu}} \right) \right].$$

Evaluation Results

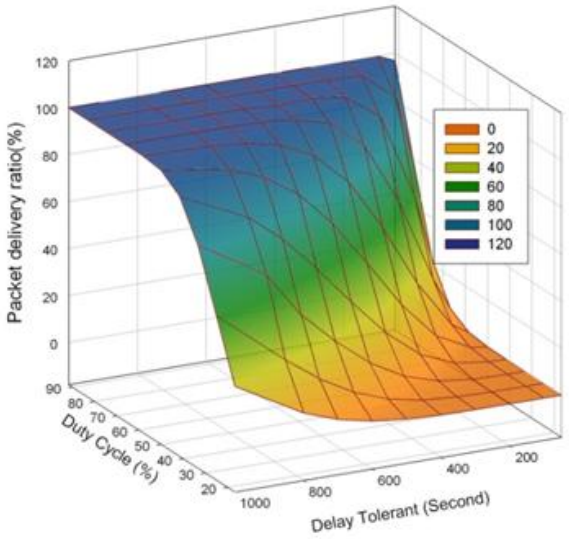
- Stable, subjected to large time scale disconnection
- Stable, subjected to low duty cycle of mobile networks

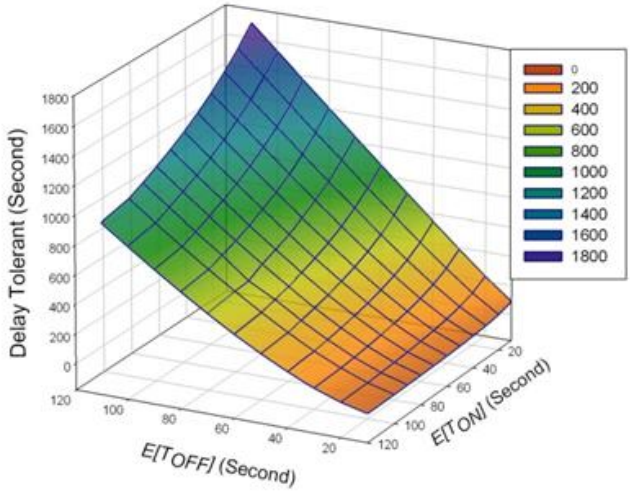




Evaluation Results

- Trade-off between energy and performance
  - Low power consumption
- Latency with different mobility models
  - Delay is under control





Demonstration

Scenario 1 Traditional ways of shopping.

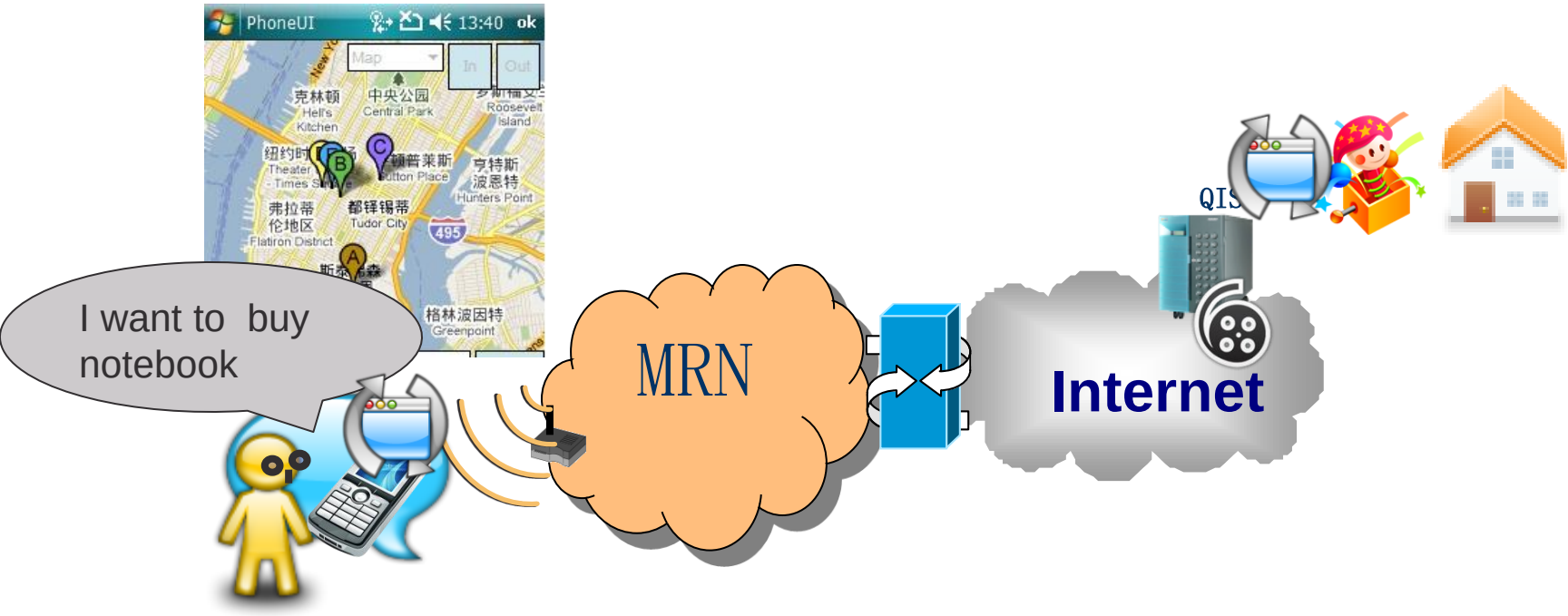
- Time table and shopping list, trip and traffic
  - Time consuming
  - Overwhelmed by massive information

Scenario 2 New fashionable ways, BTW shopping

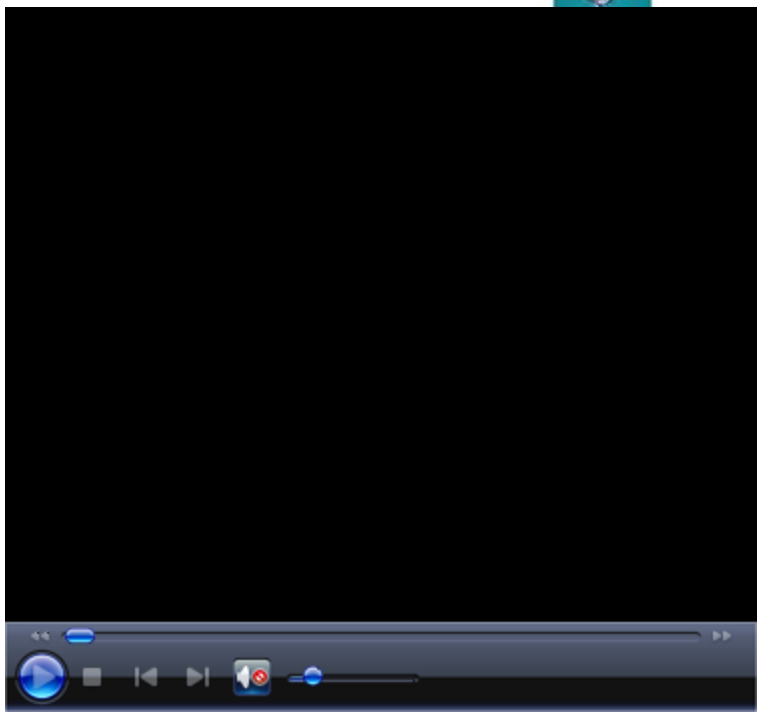
- Let shops find you on the way home
  - Just spare a while, Easy!
  - Find favorite things, Exciting!
  - Like a bee, Exploring!

Demo 1

- Traditional ways of shopping



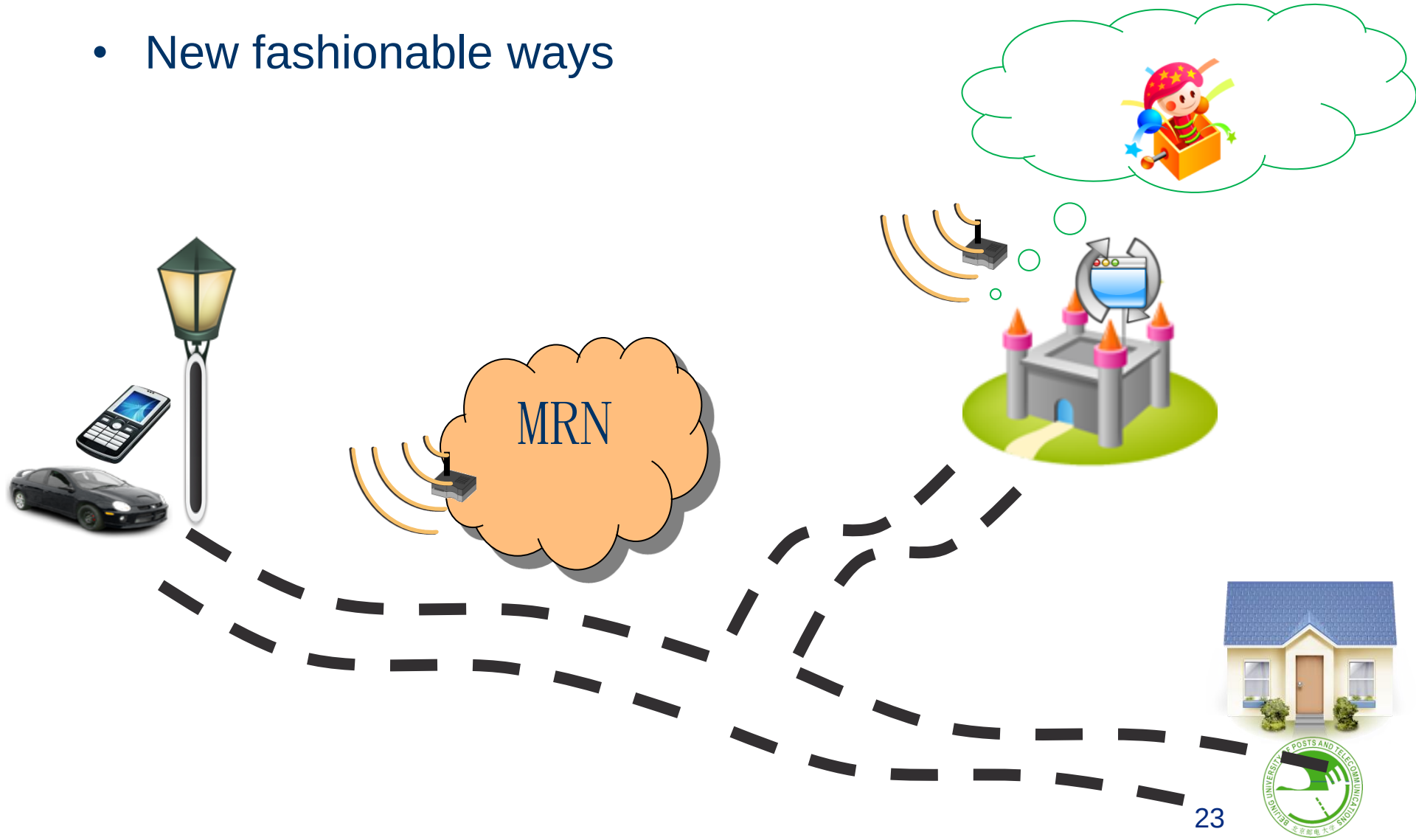
GUI of terminal devices



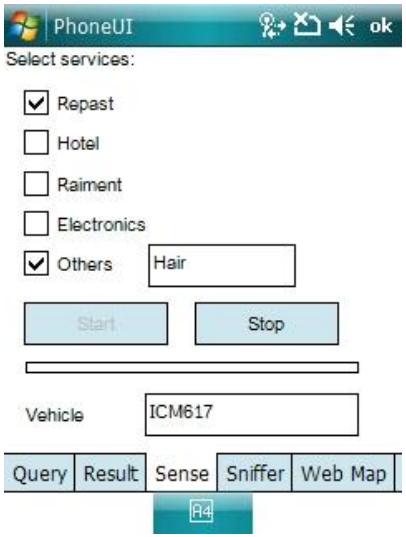
Mobile map of interesting things

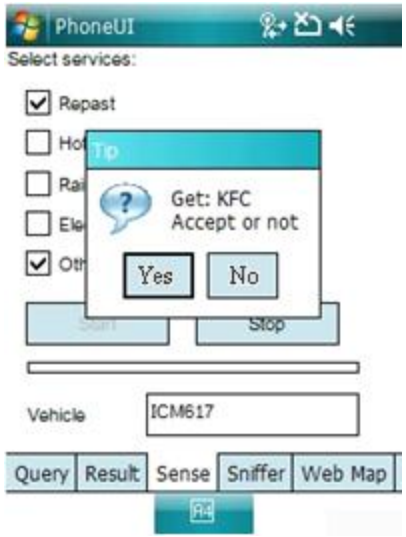
Demo 2

- New fashionable ways



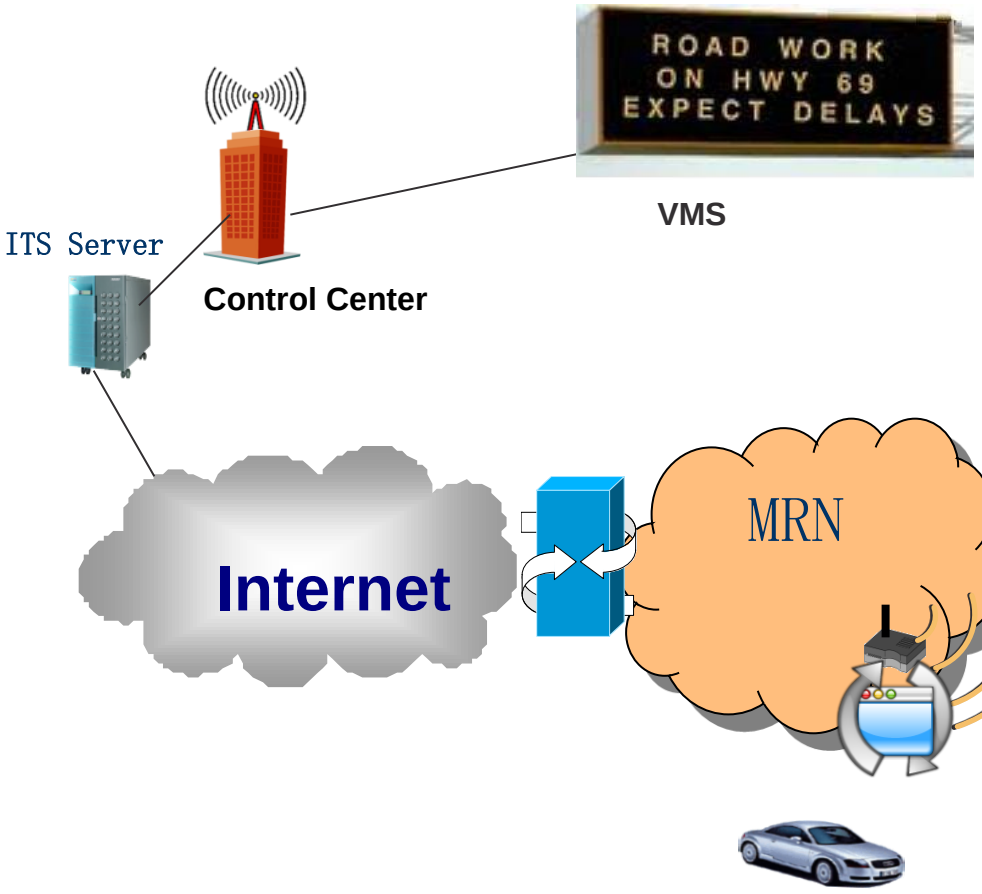
Sensing the discount information

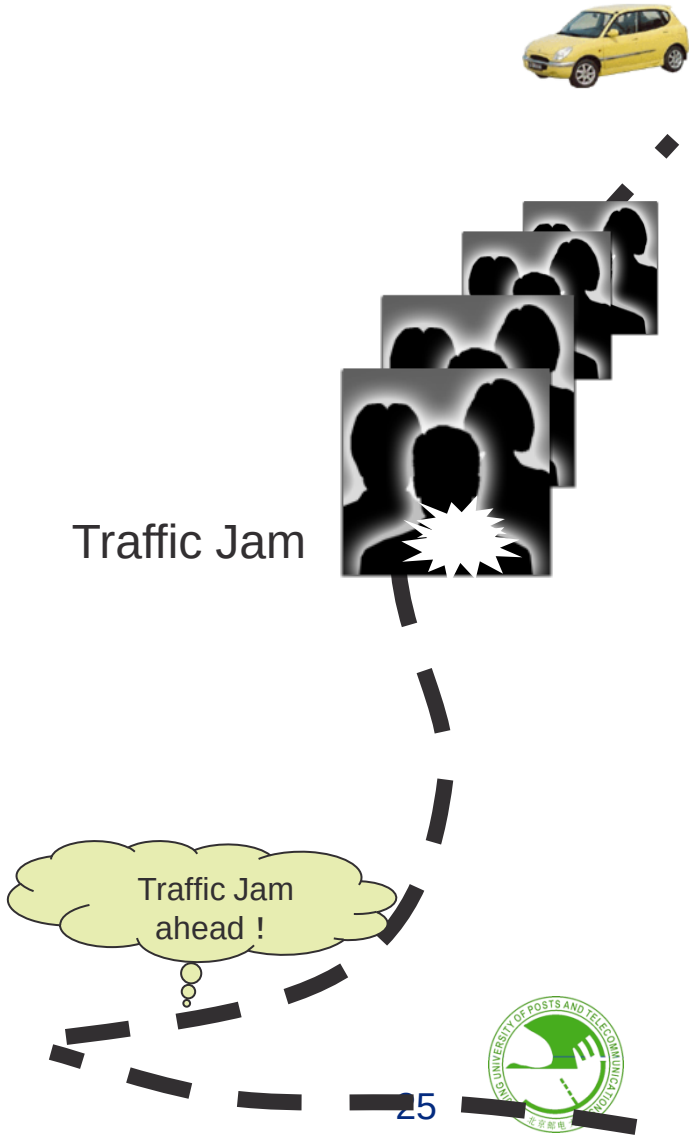




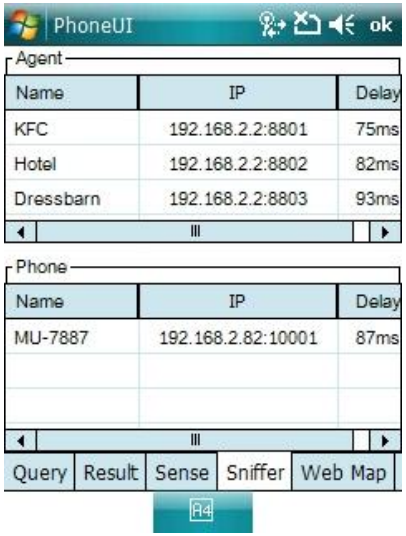
Other applications

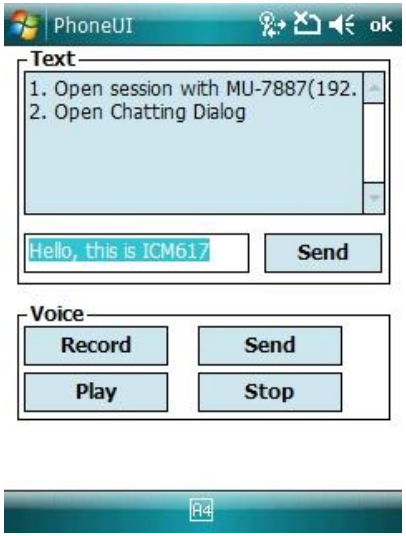
- Traffic information exchange





Sensing the neighbor vehicles





Demonstrated benefits

- Improve network convergence
  - ✓ Cover the blind spots
  - ✓ Help you be more informed
- Enhance service experiences
  - ✓ Help you be familiar with a new place
  - ✓ Help vendor make profit via new AD. Win-Win
- Apply to:
  - ✓ Local information service
  - ✓ Near range information exchange

Other considerations

- Not apply to:
  - Real time application such as video
  - Wide area communication
- Special issues
  - Information security and privacy
  - Safety and legality
  - Personal customers cultivation
  - Commercial partners join in
  - Real-life mobility and activity
  - Killer application
    - Travel information
    - Social community

Thank you!