MTFR:
Mobility Tolerant Firework Routing

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Summary of Presentation

- Background
- Conventional Potential Based Routing (PBR)
- Mobility Tolerant Firework Routing (MTFR)
- Numerical evaluations
  - Reachability analysis
  - Transmission delay analysis
  - Traffic overhead analysis
- Conclusion

Background (1/2)

- Research on future Internet is too numerous to mention
  - NSF (USA), FP7 (Europe), AKARI (Japan), …
  - Clean slate approach due to current Internet limitations
- Important requirements for the future Internet from AKARI activity
  - Large capacity: Peta-bps class backbone NW, …
  - Scalability: 100 billion devices, M2M communications
  - Robustness: Essential services (medical care, transportation, emergency services), 99.99% reliability
  - Safety: Privacy, banking services, food supply, …
  - Energy efficient: Ecology and sustainable society
  - Ubiquity: Monitoring of global environment and human society

Efficiency / Reliability / Mobility

Efficient and Reliable system including **mobility** functions is essential

Background (2/2)

Flexible Mobile System: **MANET (Mobile Ad Hoc Network)**

Efficient and Reliable System: **Nature-inspired mechanism based on physics and biology**

Potential Based Routing

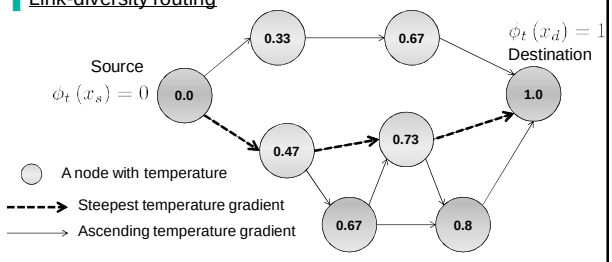
- Conventional Potential Based Routing
  - Potential Based Routing (PBR) [Basu '03]
  - HEAT [Baumann '07]
  - Link-diversity Routing [Lenders '08]
  - Potential Management based Proactive Routing (PMPR) [Kwon '09]
  - Delay Tolerant Firework Routing (DTFR) [Sidera '11]
  - Firework search for Location Aided Routing Enhancement (FLARE) [Hsu '10]

Issue: **Coping with high traffic dynamics caused by mobility**

We propose a more efficient and reliable "**Mobility Tolerant Firework Routing**" (**MTFR**)

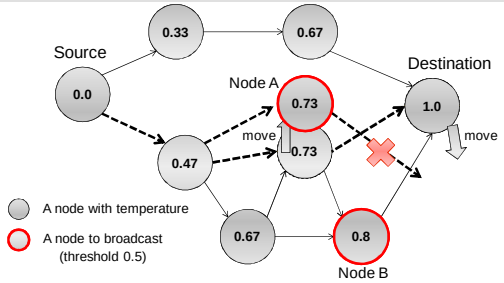
Example of Conventional Potential Based Routing

Link-diversity routing



$$\text{Potential} \quad \phi_{t+1}(x_i) = \begin{cases} \frac{\sum_{k \in nbr(x_i)} \phi_t(x_k)}{|nbr(x_i)|}, & |nbr(x_i)| > 0 \\ 0, & |nbr(x_i)| = 0 \end{cases}$$

MTFR: Mobility Tolerant Firework Routing



MTFR Algorithm

```
Initialization
for communication time= 1; 2; :::; end time do
   if condition timer has expired then
      Collection of call condition
      Adjust parameters according to status
   end if
   if temperature update timer has expired then
      for active link number= 1; 2; :::; n do
         Collection of TheirTemperature from all the neighbor nodes
         if any of TheirTemperatures has changed then   Update MyTemperature
         if MyTemperature has changed then   Send new MyTemperature
         else if MyTemperature is unchanged then   Send short message to indicate "no-change"
         else  System status failure  end if
         Receive TheirTemperature message
      end for
   end if
   if there is a packet to be forwarded then
      if MyTemperature > firework threshold then   Broadcast packet to all the neighbors
      else if MyTemperature < firework threshold then   Forward packet to the highest temperature neighbor
      end if
   end if
end for
```

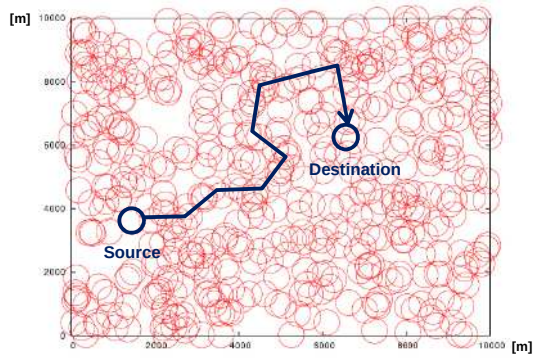
- **Temperature update timer**
- **Hop limit number**
- **Condition update timer**

This process is taken over within hop limit threshold

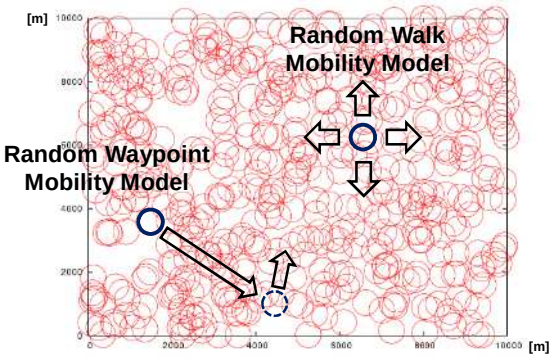
Basic simulation parameters

parameter	value
Initial layout	Uniformly random in 10km x 10km area
Number of nodes	2000 – 4000
Wireless range	100 – 500 m
Mobile node speed	1 m/s (pedestrian) 20 m/s (car) 100 m/s (bullet train)
Firework hop limit	7 hops
Firework threshold	0.5
Mobility model	RWK RWP (constant speed, no pause)
Simulation time	100 – 300 sec

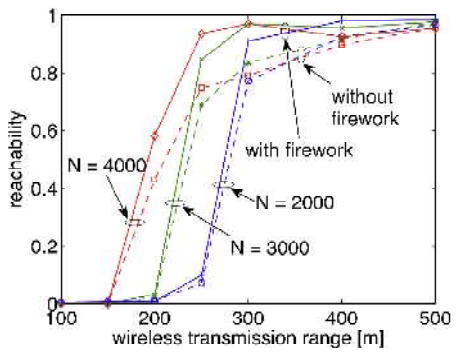
Example of uniformly random layout



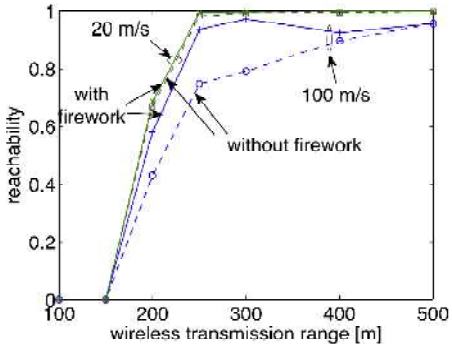
Example of mobility models



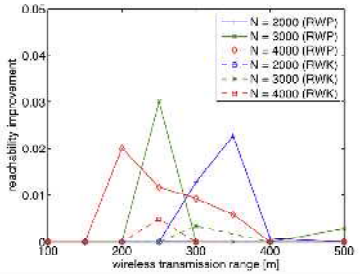
Influence of Wireless Transmission Range



Influence of Vehicular Speed



Reachability Improvement under Different Mobility Models



(*) Average distance of movement after time t passed in RWK and ODW

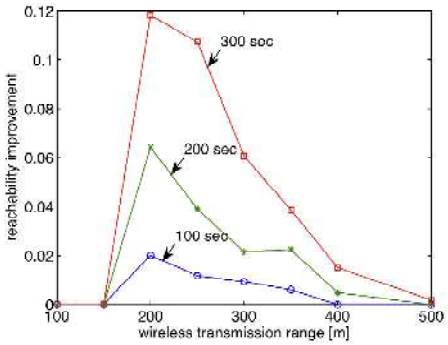
$$E[\omega_{RWK}(t)] = \sqrt{t} \quad < \quad E[\omega_{ODW}(t)] = t$$

RWK: Random Walk

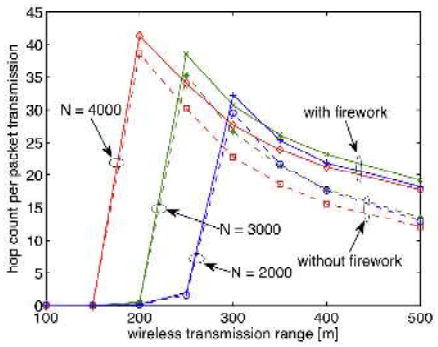
RWP: Random Waypoint

ODW: One Directional Walk

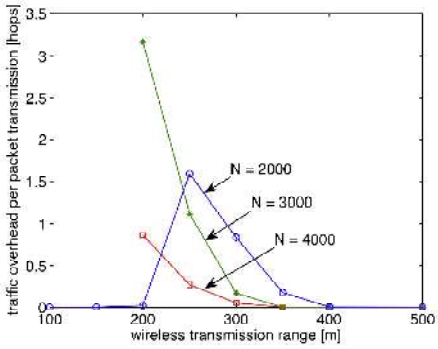
Reachability Improvement over Temperature Update Interval



Transmission Delay Analysis



Traffic Overhead Analysis



Conclusion

Summary

- Proposal of "Mobility Tolerant Firework Routing (MTFR)" for new generation mobility network with high efficiency and reliability
- Evaluated MTFR by reachability, transmission delay, and traffic overhead in comparison with standard PBR
  - Influence of wireless transmission range and vehicular speed on reachability
  - Reachability improvement under different mobility models and over temperature update time interval
    - **Large reachability improvements by firework were observed on all conditions**
  - Transmission delay and traffic overhead analysis
    - **MTFR produced better reachability than standard PBR at the expense of a small additional transmission delay and intermediate traffic overhead**

Future Work

- More evaluations on firework parameter study and theoretical analysis
- Extension of MTFR into an adaptive parameter management system

Thank you very much for your attention.

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