Providing Traveler Information in Rural Areas using Ad hoc Wireless Routing

Dr. Richard Wolff Mingliu Zhang

Electrical and Computer Engineering Department Montana State University

August 14, 2006



Outline

- Wireless coverage in rural areas
- Ad hoc networks
- Performance of conventional and new approaches
- Inclusion of terrain effects
- A practical example
- Conclusions



Cell phone coverage on Highway 191, Gallatin County, Montana



Data from WTI





I Love the convenience, but the roaming charges are killing me!



Do we really need a network?

- Is this a dumb question.....
- MAYBE NOT
- Let the users be the network!!!
- Multi-hop routing for very sparse areas



Ad hoc networking concept: already finding uses



Military applications
Public safety network trials
Standards-based and proprietary solutions available

Ad hoc networking: classical assumptions

- Line of sight paths between nodes
- Existence of multiple links between nodes
- Link persistence and error-free performance
- Terrain is uniform or irrelevant
- Always a path from source to destination
- Node density high enough to assure communications at application level



Characteristics of the rural domain

- Node density is low
- Connectivity is intermittent
- Source-destination paths not persistent
- Terrain may be a factor
- Error rates can be significant

Will ad hoc networking apply in this domain?



Rural traveler Information system

- Vehicular ad hoc network
 - No conventional wireless communication infrastructure
 - MAC layer based on 802.11 standards or similar
- Applicable to low node density, sparse rural area
- What's the appropriate routing protocol?





Mobile nodes (100 in this figure) and their trajectories

🛣 Project: ml_terrain_yellowstone_random_nodes Scenario: yellowstone2 [Subnet: top.Network.subnet_0] Traffic Protocols DES Windows Help Edit Topology File View Scenarios 3 쎯 3 5 (+ \sim_{\odot} 254400 2501/23500 2500 2019 23 2000 25003000 3001 110.0 2008 mobile 955on 250,0000 45 2500 3090 3000005600 moble node 2800 2500 45.0 2500 3 DOD 20202500 2500m 2500 2500 2500 660 500 500 20002000000 2800 多2006 250 2000 3000 36801 mobile node 4F 3000 3000 3000 2500 2500 000 2000 RABBIE hode 49 3000 2500ode 52 mobile 2298093000 250030**380025(3500** 2000 2000 mobile_node_38 3000 2500 200 2500 2588500 mobile node 13 2506 3000 2500 2500 2500 2060 2000 2500 2508 25025880 2500 node 36 mol 2500 m bile_node_1 2500 node 56 nobile node 2. 25000bile node 5 nobile node 48 Node_67 258An 57 25083880 2500 100 bile_020 8033 2500 mobile 2500 2500 2500 m bile_hode_3. nndeile node 32 mobile node Bile n886 gode 50 2500 mobile_node 42500 3000 mobile 2500 mobile_node_30 250 Bile node_31 2500 mobile mode 14 mobile_node_5 2500 node 2 2500 2500ារាល 256500 mobile node 59 25982550 ode_55 30905-30-00000 2500 mobile node 60 2500 2500 2500 mobile_node_22 31488 oderetan moh 2500 100 3000 3890 3000 mobile_node_12 mobile node 10 250500 -----2500 0025-00 mobile node mobile_hode_54 node 19 mobil 2500 mobile node 34 2500mobile_node_ 2500 mobile node 25 mobile node 4 2500 00 26600 _node_5 30000 2500 pbile_node_44 3 mobile nade 16 mobile node 41 2800 mobile_node_5%nobile_node_20 3000 mobile made 0 2000000 mobile node 3 mobile_hode_11 2509 3000 mobile 2500 mobile_hede_40 2000. 2000 ्यम 2500 2500

ENGINEERING

Simulation results using a conventional routing protocol

Route discovery time at different radio ranges when Nv=2800

Radio range (meters)	Percentage of simulations where route found	Minimum route discovery time (seconds)
100	0%	No route found
200	0%	No route found
300	72.8%	0.28
400	81.9%	0.20
500	100%	0.16

Protocol: DSR (dynamic source routing)





No assumption of the connectivity of the underlying network

•Messages exchanged when two nodes come into the transmission range of one another



Calculations- similar to epidemic routing

Number of vehicle Nv = 1400

Radio range (R) (meters)	Transit time (T) (minutes)
100	84
200	84
300	58
>=400	0

Results show promise for epidemic routing



What about terrain?



Terrain, location and trajectory information are used to determine the location of other node at any time and then determine path loss and blocking



College of ENGINEERING

Path loss and blocking calculation





Some preliminary simulation results



Average traffic received TRAIN vs unmodified DSR



College of ENGINEERING

What happens in the real world?

- Consider a real world scenario and application
- Examine terrain and develop a coverage model
- Model connectivity using ad hoc routing
- Consider implementation with commercial equipment



The highway 191 example





Multi-hop network for highway 191

- Use vehicle to roadside communications
- Form a multi-hop chain of roadside repeaters
- Use 900Mhz spectrum
 - Unlicensed
 - Longer range than Wi-Fi (2.4 GHz)



Highway 191: 15 repeater network





Network characteristics

- Repeater spacing: 0.7 to 5 miles (terrain dependent)
- Throughput: up to 160kb/sec
- Power consumption: 15 watts per node (max), solar/battery powering is feasible
- Technology: commercially available
- Applications: IP-based data



Conclusions

- Connectivity in rural areas using ad hoc network techniques is feasible
- Routing protocols that work in sparse conditions are needed
- Terrain effects must be taken into account
- Commercial products are becoming available



Acknowledgements

- Work funded by National Science Foundation
 - CMS -0339040, NSF/USDOT Partnership for Exploratory Research-ICSST: Timely and Effective Dissemination of Traveler Information in Rural Areas
 - CNS-0519403, NeTS-NBD: Wireless
 Communications Networks for Rural Areas

