What to do with NS-2

Steffen Reidt

Outline
NS-2: architecture, features
Radio propagation models
Mobility models
My algorithms and protocols evaluated with NS-2
Our Cluster Algorithm
Other application that would make sense / no sense
Conclusion

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NS-2: architecture

Physical layer:

- Event/Packet based simulator:
  - smallest entity in NS-2 is a packet, which is modeled as an event, that is executed as certain point in time. Other events change the state of the nodes (movement, wake up, destroy)
  - all events are strictly ordered by time, ordered in a list.
- Sequential execution:
  - event is on top of event list
  - (Change state of node or) decide if packet can be transmitted from A to B:
  - Compute propagation power received by B from A.
  - The transmission succeeds iff propagation power > threshold value. (discrete function!)
NS-2: architecture

Other layers:

- **MAC**: Basically 802.11, configuration possible (data rate, preamble length), but no bandwidth grading
- **Network**: AODV, DSDV, OLSR, Flooding
- **Transport**: TCP, UDP, CBR

Much more protocol developed individually but not part of NS-2 code.
NS-2: architecture

- From the user's perspective, NS2 is an OTcl interpreter that takes an OTcl script as input and produces a trace file as output.
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Radio propagation model:

- Generally Free-space and Two-ray-ground model included in Open Source network simulators
- Our implementation of an efficient ray optical radio propagation model enables:
  - Consideration of terrain and obstacles in simulations
  - Incorporation of topographical data in routing protocols and other upper layer protocols
- Interruption by buildings and reflection and deflection effects are considered
Radio propagation model

Qualitative validation of the radio propagation model with iNSpect [2]
Simulation of city area

Behavior of AODV under the consideration of buildings.
blue = sending; yellow = forwarding; green = receiving

• But unrealistic mobility remains (nodes moving randomly and ignoring obstacles)
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Existing mobility models

Existing mobility models:

- **Random mobility models** (Random Waypoint, Random Direction, Gauss-Markov): Do not provide realistic mobility scenarios for tactical networks, where soldiers are moving in formations.

- **Graph Model**: Used to simulate especially vehicular networks. Nodes are moving on predefined paths with autonomous speed and direction.

- **Obstacle Mobility Model**: Nodes are tracing their predefined or randomly chosen goal on the shortest path considering the obstacles.

- **Group mobility models**: Rudimentary implementations directly in NS-2 where a group is moving with constant relative positions between the nodes $\Rightarrow$ No possibility of simulating tactical networks which are likely to change their formation.
Coalition Mobility Model

Coalition Mobility Model:

- Combination of Graph and Group mobility model plus formations modeling
- The logical center of the group traces one of the predefined paths
- A group moves relative to the logical center and is likely to change its formation
- Formations in our simulation for small unit light infantry are defined according to the FM 7-8 field manual [4]
- Realization as extension of the mobility model generator CanuMobiSim [1] by functionality for group movements
Paths for groups

Defining paths for group mobility model
Organization of groups

- Hierarchical organization of groups enables definition of elaborated mobility scenarios with low configuration effort.

- Groups consist of nodes and subgroups which can change their formations (E.g. a platoon consists of single nodes such as the platoon leader and squads. The squad itself consists of fire teams as subgroups and squad leaders as single nodes and the fire teams consist of 3 or 4 single nodes).

- Groups and formations can easily be defined in an XML file.
Definition of a group in EBNF

definitions:
  distance = "real number"
  angle = "real number"
  name = "string"
  node = distance angle
  formation = name {{node} {group}}
  group = name formation {formation} [distance angle]
Result: Improved simulation scenarios for Tactical networks

Platoon crossing city area
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Cluster algorithm:

- **Probabilistic:**
  - Zongpeng [5]: Probabilistic Power Management in WANETs
  - Send Hellos in 0.2 sec to determine number of neighbors
  - Own decision to be CH with prob $\sim \frac{1}{\text{number of neighbors}}$

- **Deterministic:**
  - Amis [3]: Exchange information possibly in several rounds
  - Send Hello messages in 0.2 sec to know neighbors and their IDs
  - Every node chooses node with highest ID as his clusterhead (and thereby forces this node to be clusterhead)

**Examination:**

- Existing cluster algorithm change 10 to 50% of the cluster heads after every hello message, depending on mobility.
- Sending Hello message in 0.2 sec frequency kills nodes in NS-2 with standard settings in one to 3 minutes.
Our cluster Algorithm

Modification of Amis’ cluster algorithm

• Retained structure:
  • d-hop cluster
  • no gateway nodes
  • no partition in fix clusters, usual nodes connect dynamically to cluster heads
  • ⇒ avoidance of communication overhead and chain reactions of cluster head changes

• Modifications:
  • Replace node Id as decision factor about CH by Quality factor
  • Increase the broadcast frequency to \( \geq 8 \) seconds
  • Incorporate mechanism to decelerate changes of CHs
Parameters to consider

- Quality factor might consider:
  - Trust
  - Battery level
  - Certainty of connection (Distance)
  - Degree (number of neighbors)
  - Routing (use nodes which are already involved in routing process to save energy)
  - Bandwidth (Do not choose node working already on full capacity)
  - Topography (Do not rely on a route that is likely to break down due to an obstacle)
  - Attack probability: type (tank, soldier); communication activity

- One metric for every property
- Combine the metrics to one quality factor $\in [0, 1]$
- Breach of side condition $\Rightarrow$ quality factor $= 0$
Combination of metrics

- Create one final quality factor as a linear combination of the part metrics s.t.
  - Every loading factor ∈ [0, 1]
  - Sum of loading factors = 1
- Example considering node Id and battery level:
  - Loadings: (1,0) (1/3, 2/3) (2/3, 1/3) (0,1)

![Graph showing number of nodes over time](image-url)
Distribution of data

- Application: *Distributed key generation algorithm, non-interactive hierarchical key generation*

Static hierarchical structure of platoon in city area.
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Other application (simulations) that would make sense / no sense

Yes: (Lower layers)
- Routing algorithms under the consideration of application parameters (movement, terrain)
- Algorithms that are only dependent on relative but not absolute timings. (Time for receiving, sending message is device dependent.)
- Protocols, that spread some information/knowledge through the network. (trust models, cluster algorithms)

Critical: (Application layers)
- The higher you get in the OSI hierarchy, the more the mistakes from the physical layers might be multiplicated.
- The results from (data-oriented) applications that are build on multi-hop communication (routing) are always questionable. (Such as my simulation on the dissemination of key material.)
CanuMobiSim.
http://canu.informatik.uni-stuttgart.de/mobisim/.

iNSpect.

