IBM Research

Inter-Domain Routing for Mobile Ad Hoc Networks

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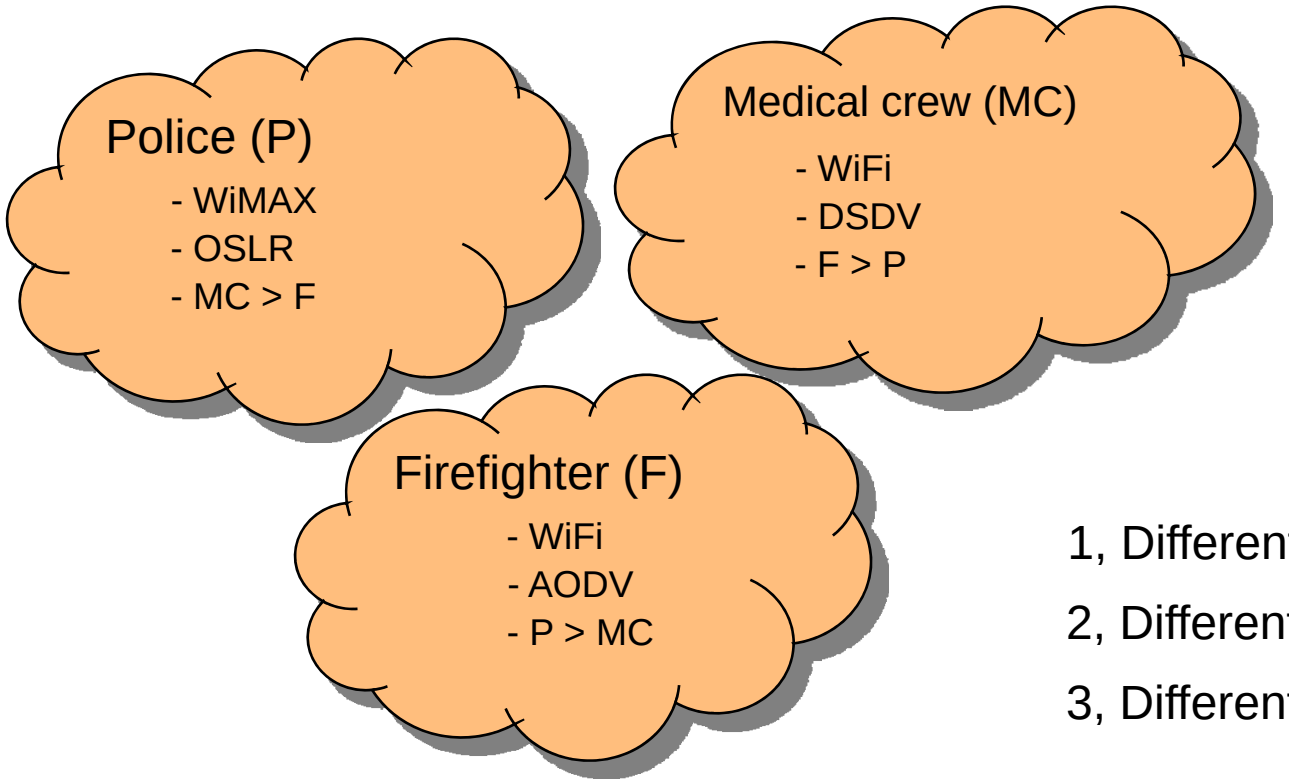
Heterogeneous MANETs



1, Different technologies

2, Different routings

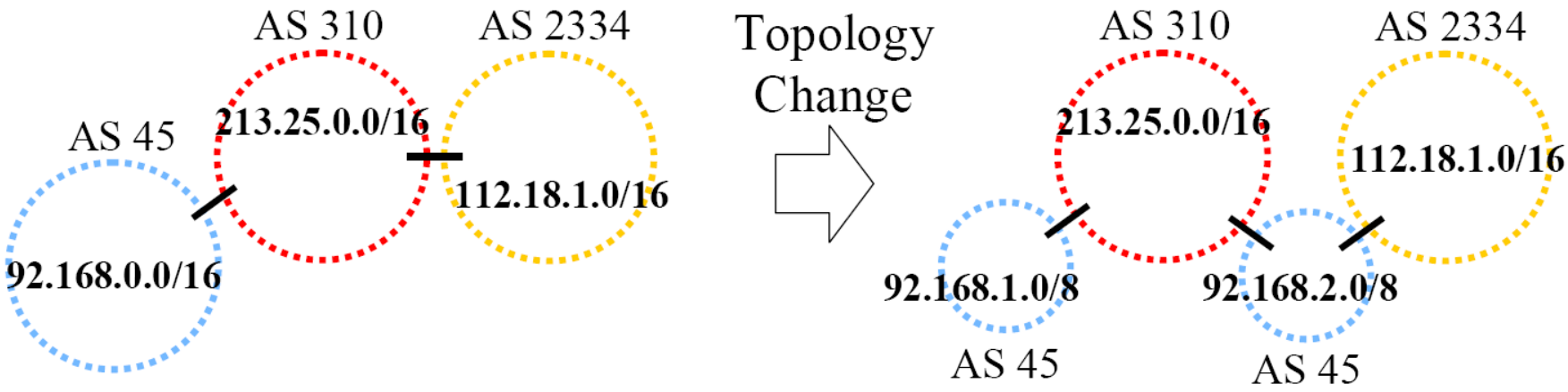
3, Different policies

How can we enable interoperation between heterogeneous MANETs ?

Interoperation among MANETs

- Challenges from different layers
  - e.g. PHY, MAC, routing, policy, security, etc.
- We focus on the problem at inter-domain routing
  - In the Internet, inter-domain routing is done by BGP
  - The principle of BGP is to enable opaque interoperation
    - Each domain has the administrative control over its intra-domain routing protocol and inter-domain routing policy

Inadequacy of BGP for MANETs



Topology change can be arbitrary

- Difficult to do IP aggregation
- Loop detection base on AS number will fail

Inadequacy of existing ad hoc routing for MANETs

- Hybrid routing protocols
  - Their main goal is to improve the performance in a *single* domain via adaptation
- Cluster-based routing protocols
  - Can use hierarchical routing and achieve a scalable routing solution in a *single* domain
- Cannot support the interaction of multiple domains with different routing protocols
  - e.g. Policy support, reactive vs proactive domains, etc.

Design of IDRM

- Gateways:
  - Relative more powerful
    - Handling inter-domain routing
    - Able to do translation between MANETs at physical, MAC, and network layers
- Non-gateway
  - Relatively less powerful
    - Communication to nodes in other domain thru gateways
    - Know the IDs of the gateways
- Goal: Same as BGP, to provide opaque interoperation

Design Issues

- Handling Domain-level Topology Changes
- Membership Management and Announcement
- Policy Support
- Data Plane Operations

Handling Domain-level Topology Changes

- A single domain may be partitioned into multiple MANETs due to node mobility and the gateways in the domain must detect the event
  - Proactive domain: easy, read the route table
  - Reactive domain: more challenging, need to probe
- IDRM approach: gateway send beacons to other gateways
- Generate new MANET IDs
  - MANET ID = Domain ID + Hash(G_1,G_2,…,G_n)
  - Encode the domain ID in the new MANET ID to support a dynamic policy translation

Membership Management and Announcement

- Gateways advertise the IDs of the nodes that they can reach
- Cannot rely on IP prefix for routing between domains due to arbitrary partitions and merges
  - Re-assign IDs: large overhead
- In IDRM:
  - Small size MANETs: plain text
  - Other compression approaches (e.g. Bloom Filter) can apply for larger MANETs

Policy support

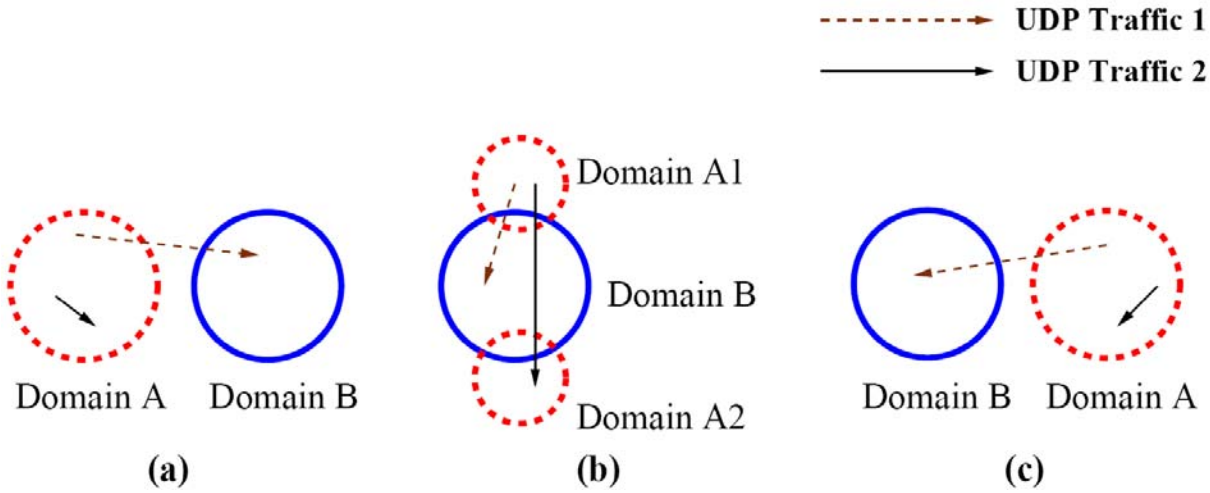
- In IDRM, inter-domain routing policy is enforced in a similar same way as in BGP
  - Policy is working on MANET(AS)-level
- Necessary to have mechanisms to automatically translate the original policy when such topology change happens
  - e.g. Domain A partitions to Domain A1 and A2
  - Dynamic policy refinement
- We have more discussions in IEEE Policy 2008

Data plane operations

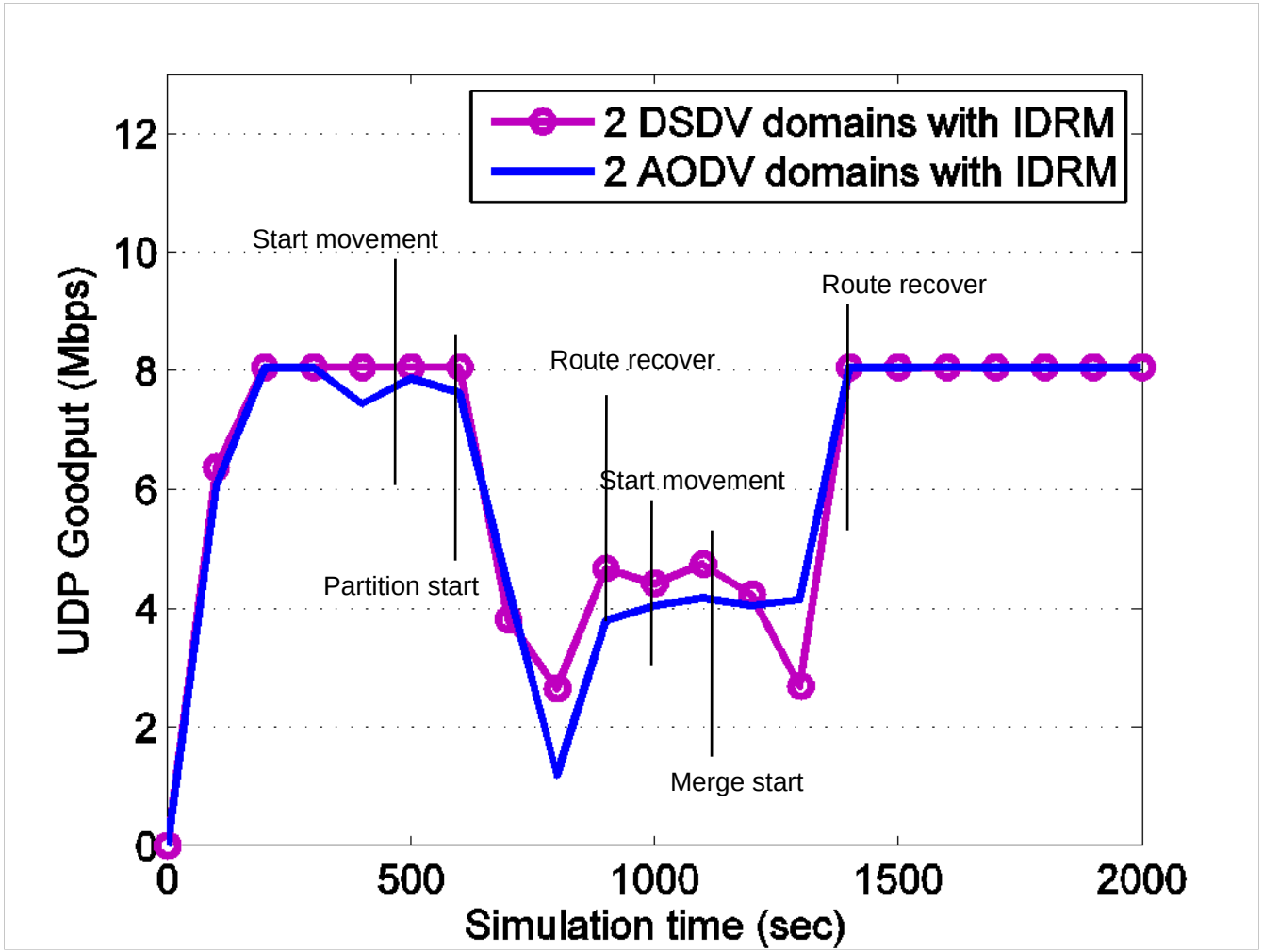
- When a gateway receives a packet
  - Intra-domain : handle by underlying ad hoc routing
  - Inter-domain : data packets will send to one of the reachable intra-domain gateways, and the gateway will do the tunneling

On-going work with preliminary results

- Performance evaluation of IDRM
  - Using ns-2
    - Different mobility model and speed
    - Route propagation delay
    - Application performance, e.g. UDP goodput and delay
    - Overhead analysis



Simple group mobility results



Conclusion remark

- Identified the challenges of inter-domain routing in MANETs and proposed IDRM as a viable solution
- Discussed the operations of IDRM
- Next steps
  - Policy, security, optimization, etc.

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