Adapting Distributed Hash Tables for Mobile Ad Hoc Networks

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Mobile Ad Hoc Networks and DHTs?

- **Scenarios for large MANETs**
  - Disaster scenario / emergency response teams
  - Campus scenario / loosely organized groups
  - Mass events / police squads
  - Military use / troops

- **No central components available**
- **Full decentralization**
- **Basic demand for managing and exchanging data**

Distributed Hash Tables for Ad Hoc Networks?

- **DHTs are know to be**
  - Fully decentralized
  - Scalable
  - Fault tolerant
- **More rigidly constrained than unstructured P2P relationships between**
  - Relationship between Nodes (constrains connections)
  - Relationship between Nodes and data items (constrains data location)
- **Higher maintenance cost**

→ **MANETs are challenging environments for DHTs**

Overview

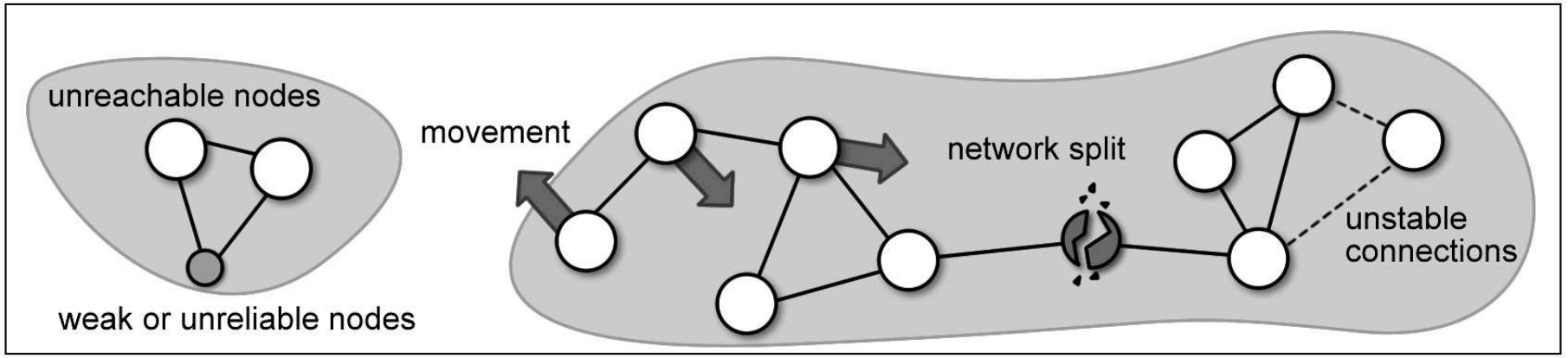
- Differences MANET vs. Internet
- Overlay-level adaptations
- Node-level adaptations
- Routing-level adaptations
- Conclusions

MANETs vs. Internet from a DHTs point of view

Assumptions made by conventional DHTs

- **Assumptions made by conventional DHT approaches**
  - Stable network
  - Long lasting connections
  - Stationary peers
  - Relatively high bandwidth
  - Hierarchical structure – efficient underlay routing
  - Efficient connection establishment
  - Dedicated routers
- **These assumptions can not be made in mobile ad hoc networks!**

Structural Differences: Ad-Hoc Networks vs. Internet



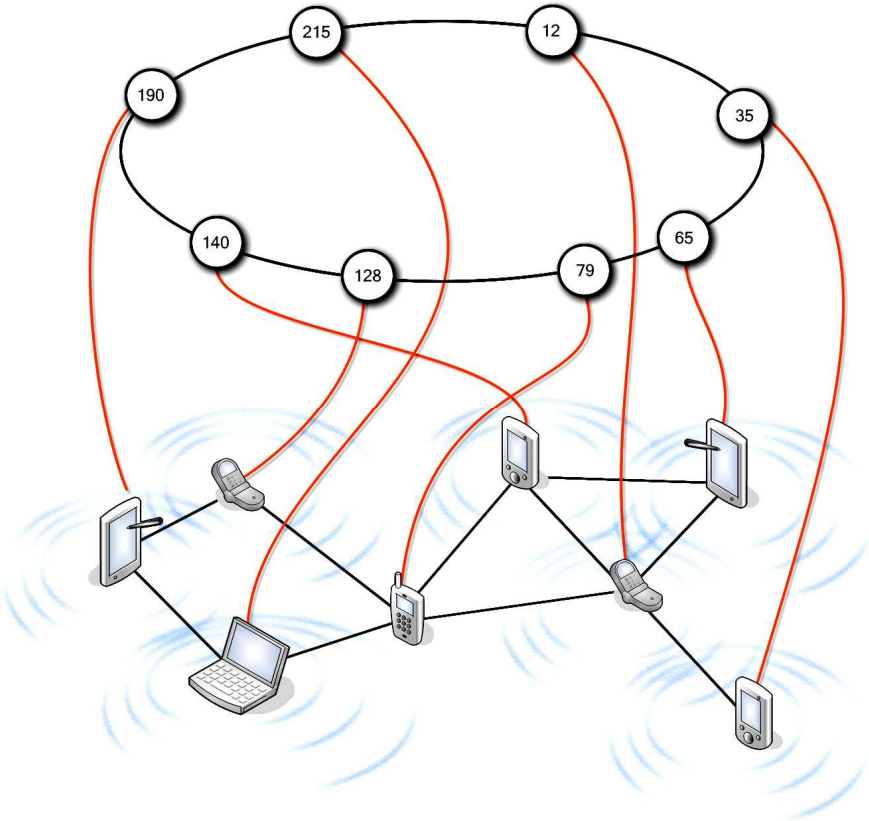
- **No global connectivity but local domains**
  - Network splits, mergers, no central services
- **Heterogeneous networks**
  - Unreliable nodes and unreliable links
  - Changing network characteristics
  - Unpredictable router behavior
- **Underlay characteristics**
  - Expensive connections, high initial cost & delay, scarce resources

Overlay-level Adaptations

How can you find a DHT in a MANET?

- **Problems**
  - No global connectivity
  - No rendezvous points or IP caches
  - DHT discovery necessary
- **Possible solution: restricted flooding**
    - Efficient
    - Identify close DHT nodes
- **Multiple DHTS can be discovered**
  - Decide which DHT to join (size, connectivity)

How robust are DHTs in MANETs?



- **MANET splits up**
- **DHT view: many nodes fail simultaneously**
- **How robust must a DHT be?**
  - Robustness via redundancy
  - 300 nodes, 2 equally sized parts
  - 6 successors: 90% failure prob.
  - 12 successors: 4% failure prob.
- **Redundancy is expensive**
  - Maintenance
  - Path finding
  - Copying of item backups
- **Redundancy limits the scalability of the system**

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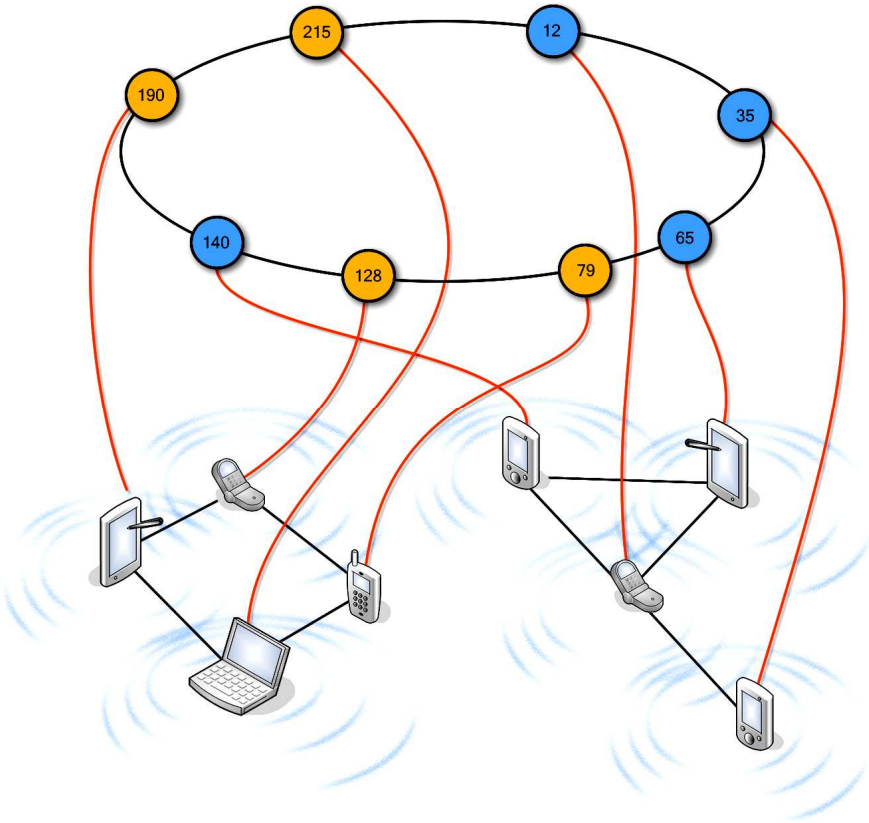

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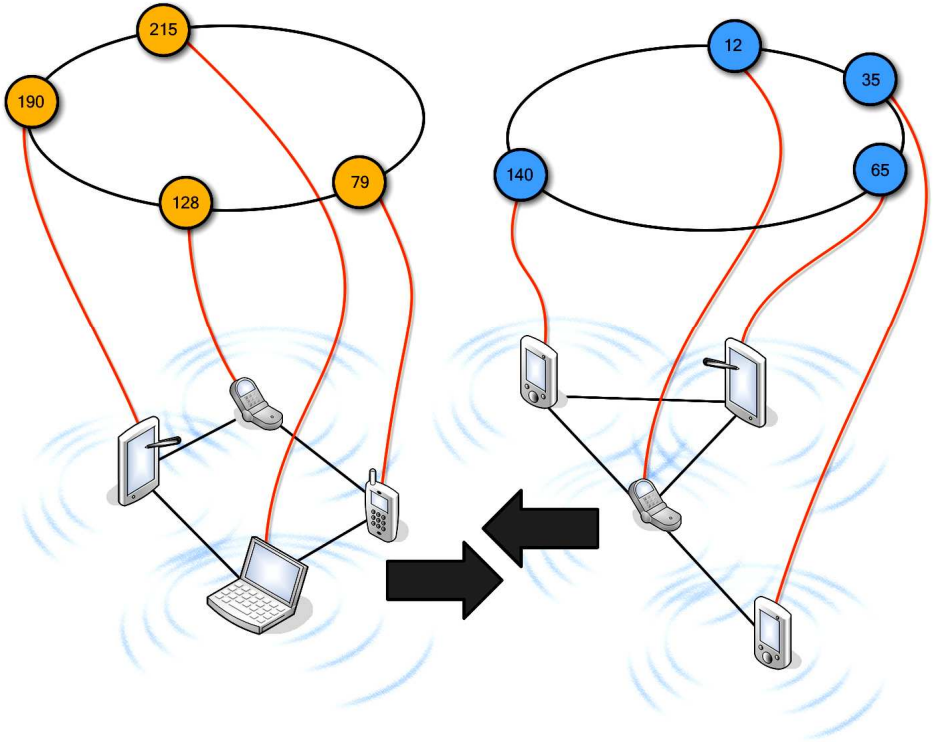

- **Multiple DHTs in one MANET**
- **All data items should be accessible over the DHT**
- **Data items are stored in one of the DHTs**
- **Merge DHTs**
  - Many data items have to be moved
  - Topological changes
  - Costly
- **Communication between two DHTs**
  - Decreased performance
  - Further splits lead to fragmented DHTs

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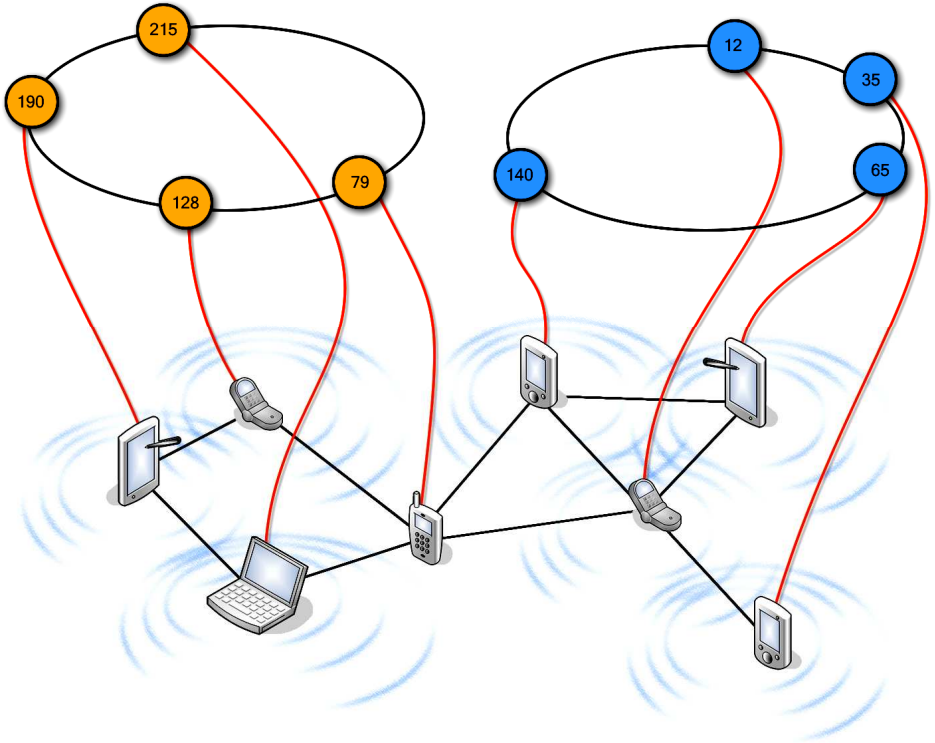

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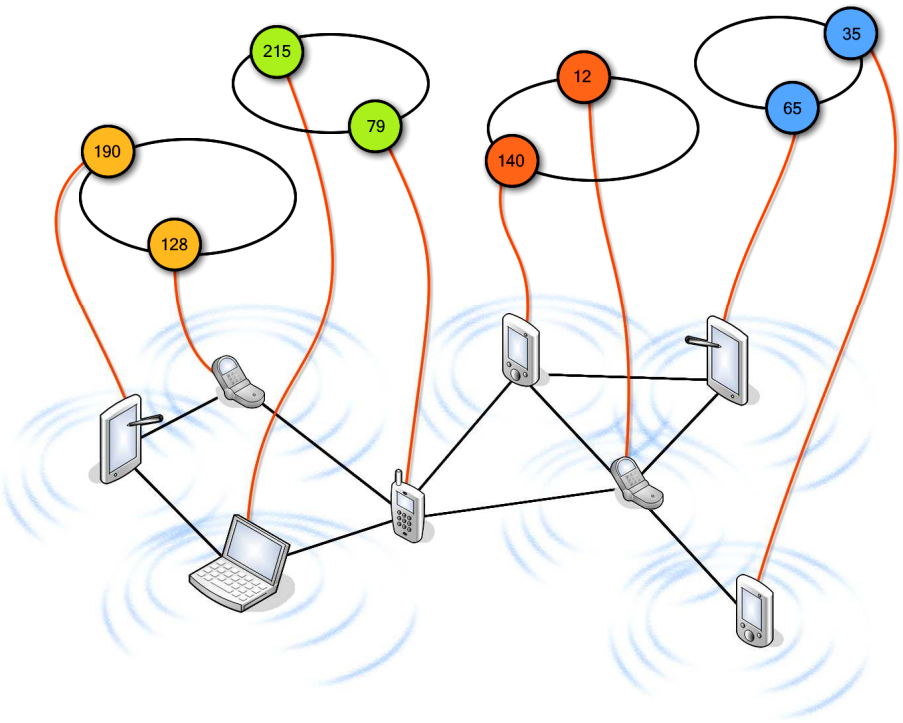

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Simple merging scheme

Goals:

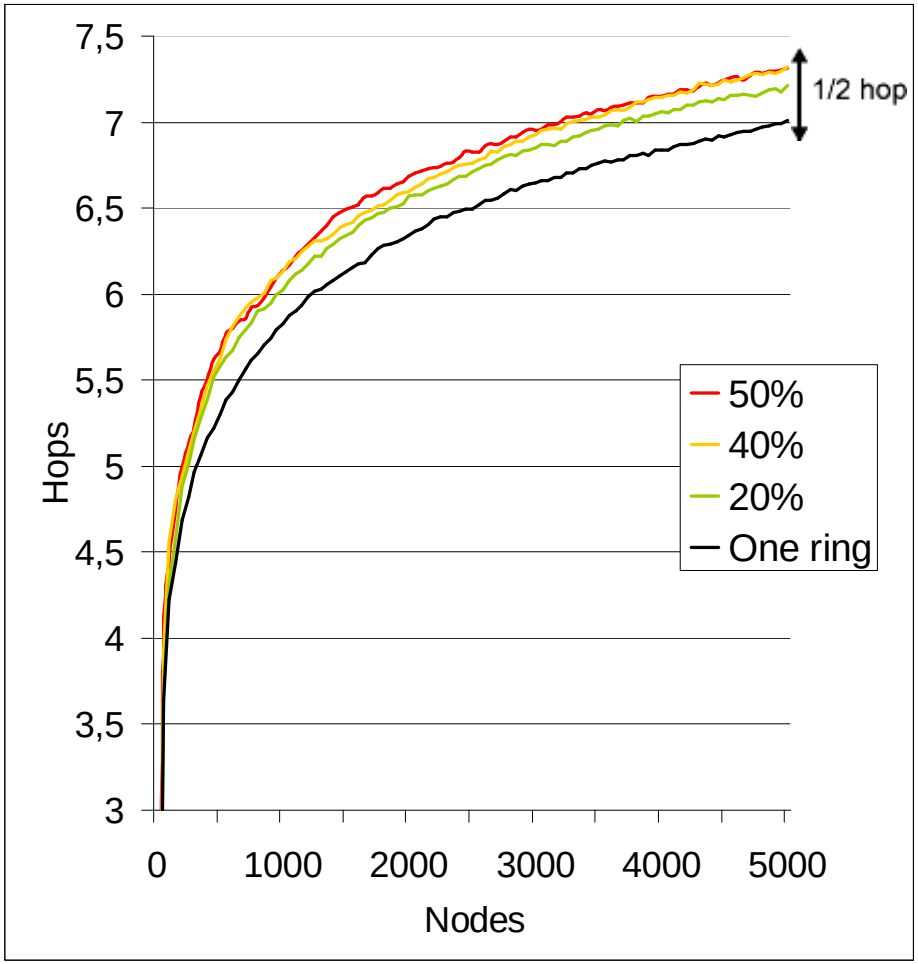
- **Move as few items as possible**
- **Establish as few new connections as possible**

! Different DHT topologies require different merging schemes

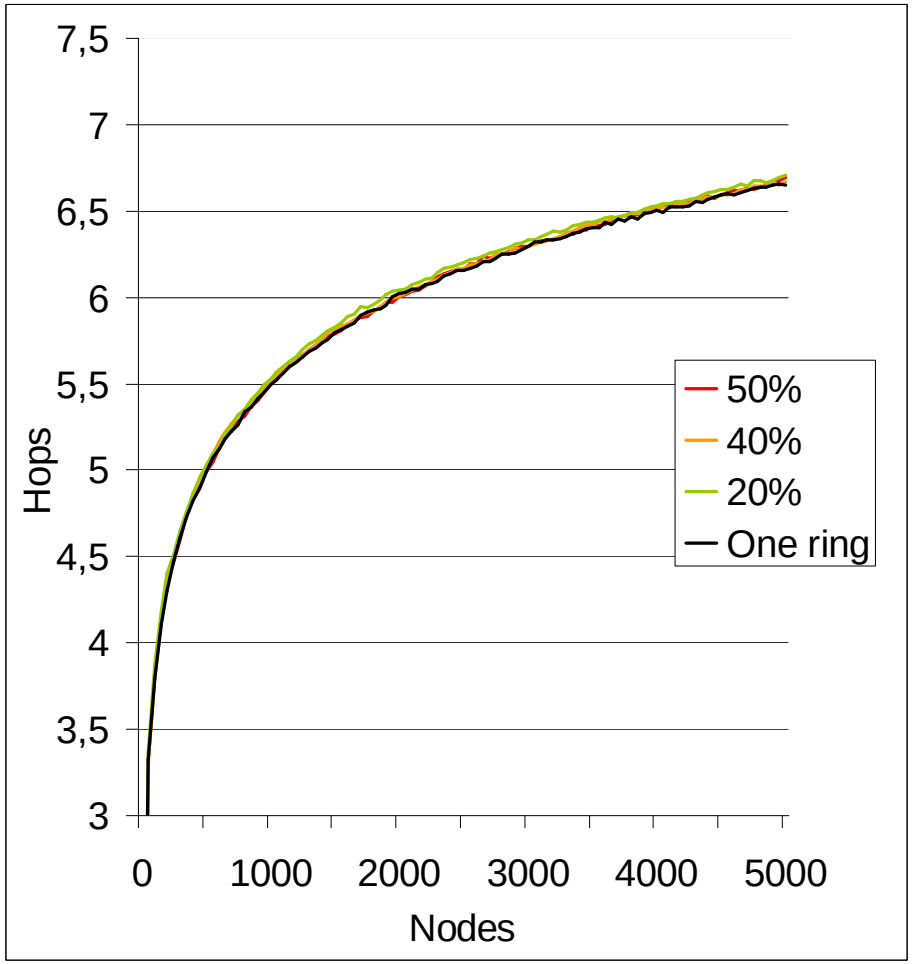
Solution:

- **Keep the identifiers of each node**
- **Keep flexible links (e.g. fingers in Chord)**
- **Adjust constrained links (e.g. ring connections in Chord)**
- **Move nodes from the smaller to the bigger DHT**

Merging scheme performance



- **One successor per node**



- **Four successors per node**

Node-level Adaptations

Weak or unreliable nodes

- **Nodes can be disconnected from the network**
- **The node is still operational**
- **Temporary disconnections**
- **Recovery mechanisms cause overhead**
- **Recovery is unnecessary if node reenters the MANET**
- **Possible solutions:**
  - Delay maintenance operations
  - Backup nodes (neighbors) perform the tasks for absent nodes
  - Build DHT of reliable subset of nodes (node ranking)
- **Increased robustness and fewer maintenance operations**

Weak links

- **Unreliable underlay links**
  - Weak, short lived, only temporary available
- **Using these links for a DHT is costly (recovery)**
- **Solution: Force network splits**
  - Identify and tag weak and unreliable links
  - Indicators: link lifetime, signal strength, node properties
  - Don’t use these links for DHT traffic
    - Requires: traffic classification on routing level (DHT control traffic)
    - Requires: classification of route finding requests (DHT induced requests)
- **Virtual partitioning into reliable sub networks**

! **But: not all data items are accessible**

Routing-layer Adaptations

Routing topologies

- **MANETs and DHTs are routing topologies**
- **Similar or duplicate functionality**
  - ID propagation
  - Neighbor discovery
  - Failure detection
  - Routing
- **Both routing instances are unaware of each other**
- **Cross layer modifications**

Cross-layer optimizations

- **Use the underlay to propagate DHT IDs**
  - Information about close DHT nodes
  - Additional DHT routing information for free
- **Use multicast for maintenance messages**
  - Efficient message delivery
  - ! BUT: numerous multicast groups
  - → Applicability depends on the choice of the underlying MANET protocol
- **DHT aware underlay routing**
  - DHT nodes are MANET routers
  - Each forwarding node has DHT routing information
  - Use DHT information to relay packets
  - Shorter overlay paths

Conclusions

- **Problematic combination of two dynamic routing layers**
- **Affects overlay, node, and routing levels**
- **Solutions must address all levels**

Thank you for your attention.

Questions?