

# Content-Centric Wireless Networking

Vikas Kawadia  
Network Research  
[vkawadia@bbn.com](mailto:vkawadia@bbn.com)

Raytheon BBN Technologies

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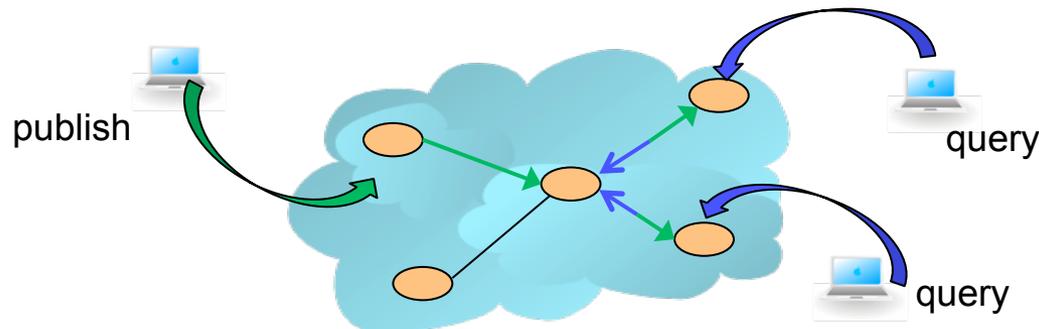
# Problems with Today's Communication Networks

- Networks are used inefficiently as simple *content-agnostic bit pipes*
  - The fundamental primitive provided is the ability to communicate with an end-point
  - Content access requires end-to-end connectivity
  - Critical links are potentially overloaded with several redundant copies
- Information search and access *depend* on connectivity
  - No search possible without access to a search engine on the Internet
  - Useful information often available locally – especially in mobile and disrupted environments – cannot easily be found
- Security semantics are point-to-point, hence often inappropriate
  - Current technology attempts to secure the *pipe* instead of the content
- Network-wide resource utilization is poor
  - Spare resources in the network cannot easily be used by other nodes



# Content-centric Networking

- Fundamental primitive is access to a piece of content/information
- *Network* manages the content, not the end-points
  - Network is aware of the content
  - Links (and other network resources) can be used more efficiently
  - A piece of content should not have to travel a link more than once
- Content is decoupled from its source/owner
  - Naturally suited to mobile and disconnected environments



# Content networking is a natural fit to mobile and disrupted scenarios

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- Decoupling content from producers is great for disruption tolerance
  - Content producers do not have to be available or reachable for content access
- Storage being a network service removes dependence on end-to-end connectivity
  - Local routers can store the content for users with common interests
- Content makes network access technology, secondary
  - Wifi, Bluetooth, 3G can all be used simultaneously
- Point-to-point routing in mobile ad hoc networks is hard
  - Content-centric networking might be a lot easier

# Some current approaches

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- Content delivery networks
  - Consists of commercial networks of caches
  - Akamai is the predominant player
  - Not easily applicable to wireless multi-hop networks
- Distributed Hash Tables (DHTs)
  - Provide for distributed storage in overlay networks
  - Assumes the underlying network is a clique, i.e., any node can connect to any other node (via IP for example)
  - Difficult to guarantee in mobile environments
- CCNx project led by Van Jacobson provides architectural solutions

# Challenges for content networking in MANET/DTNs

- Consider a wireless ad hoc network with mobility and disconnections
- Nodes publish and query for content
  - *Publish(key, value)*
  - *Query(key)* should return *value*
  - Network has finite bandwidth and storage
- Key issues:
  - How much redundancy to create and maintain while publishing and where?
  - How far should queries go?
  - How much topology state to maintain?
    - Global routing state is likely worthless in a DTN
  - What's a user's utility function like?
    - Response latency due to a disconnection probably dominates

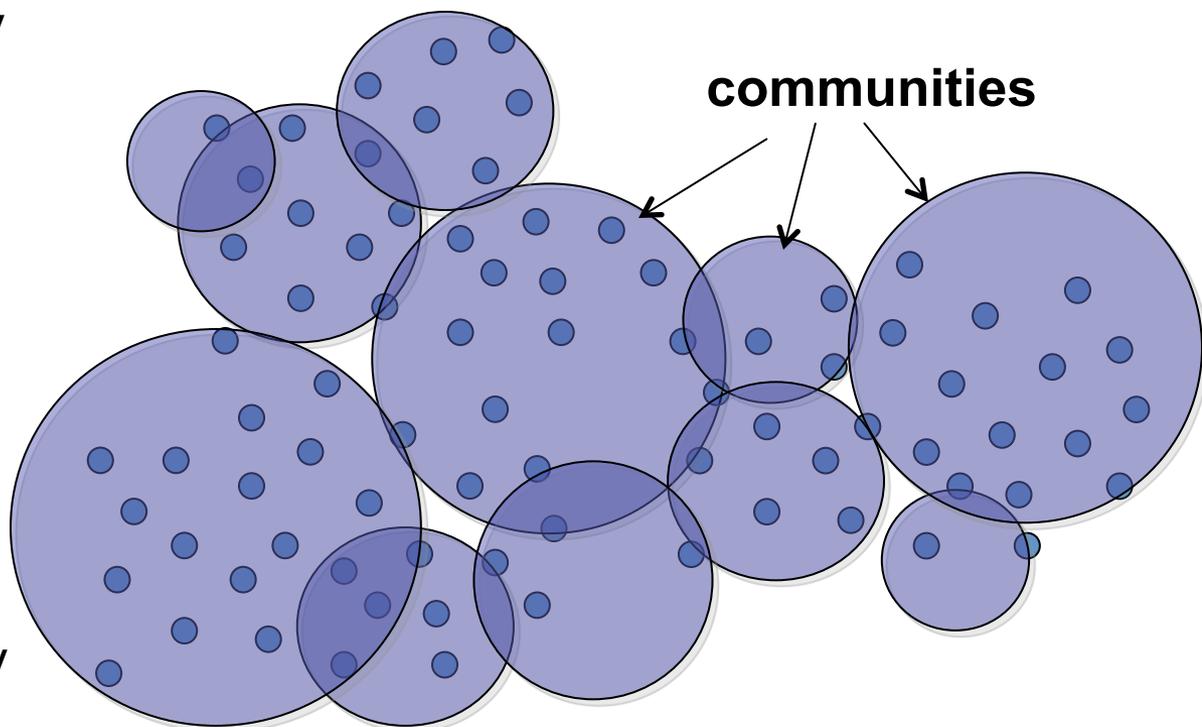
# Slinky: A solution for MANETs and DTNs

## Combine dynamic community detection with distributed replication

Communities is a grouping of the nodes in the network so that intra-group connectivity is more stable than inter-group connectivity

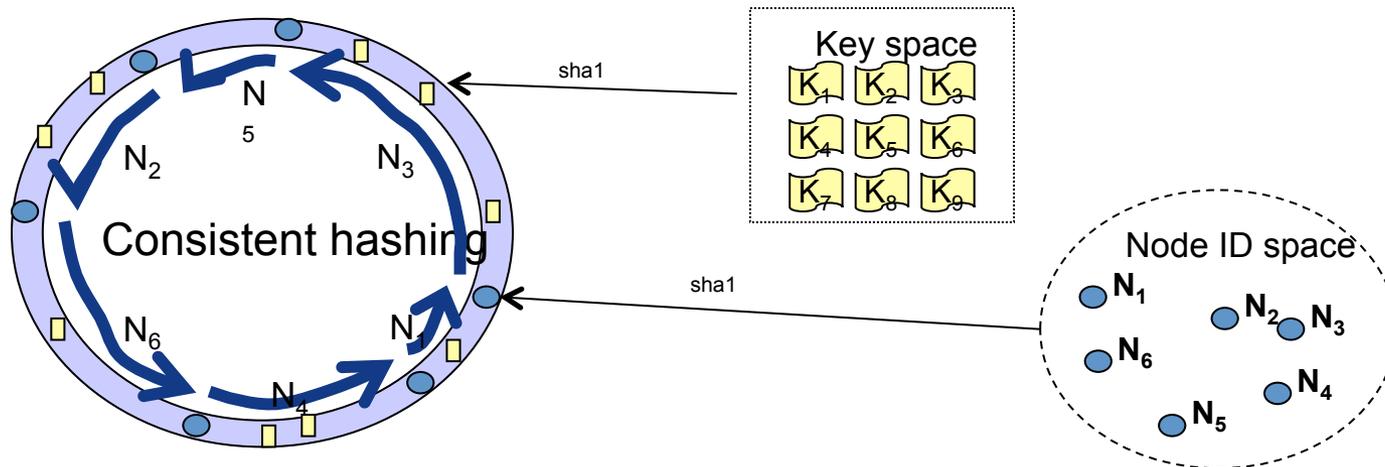
Communities reflect instantaneous structural information as well as temporal evolution of the network

Communities co-operatively store content of interest

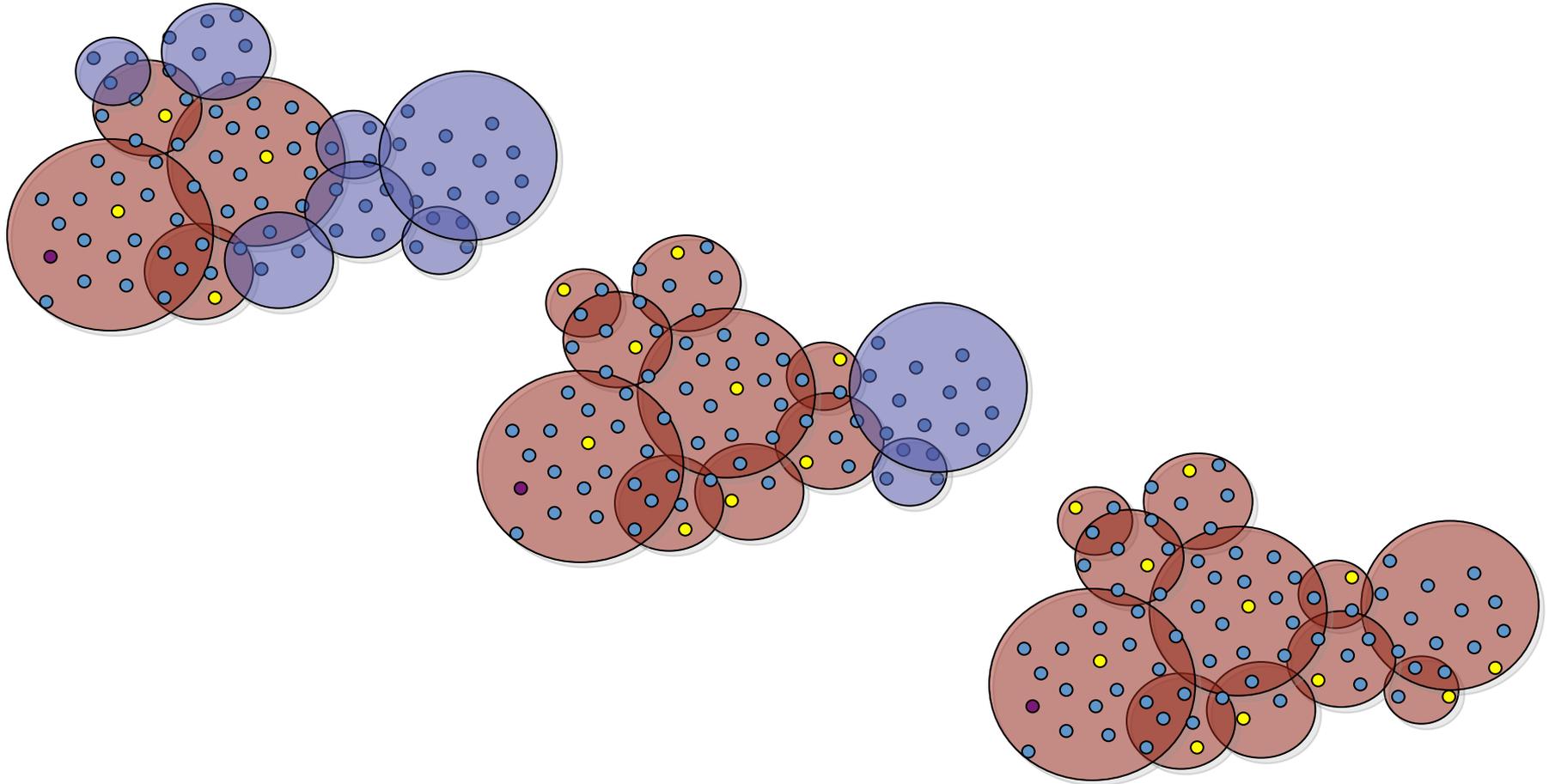


# Consistent hashing based storage within a community

- Each community forms a DHT
  - Load balances storage
- No global topology knowledge required for publish and query
- Includes a mechanism for efficient synchronizing between nearby groups when the topology changes



# Content Propagation with Time



- Content is forwarded to each community network-wide
- Queries can be satisfied locally

# Slinky's salient features

- Distributed algorithm to detect dynamic communities
- Distributed replication within a community
- Does not need global topology information
- Adapts to mobility and network changes
- Content-Centric routing in MANETs and DTNs can scale to large network sizes

# Future of content networking

- Could be crucial for improving wireless broadband efficiency
- Need for speed
  - Wireless spectrum is limited (unlike fiber)
  - Most plans have usage restrictions and/or overuse fees
- Content networking allows users to retrieve content locally via any network technology
  - Wifi (AP and ad hoc), Bluetooth, GPRS can all be used
  - Upcoming Wifi-Direct standard allows devices to be simultaneously in AP and ad hoc mode
  - Can all be made transparent to users
  - Information access possible even when disconnected from the Net
- Carriers can support more users per cell