

Content-Centric Wireless Networking

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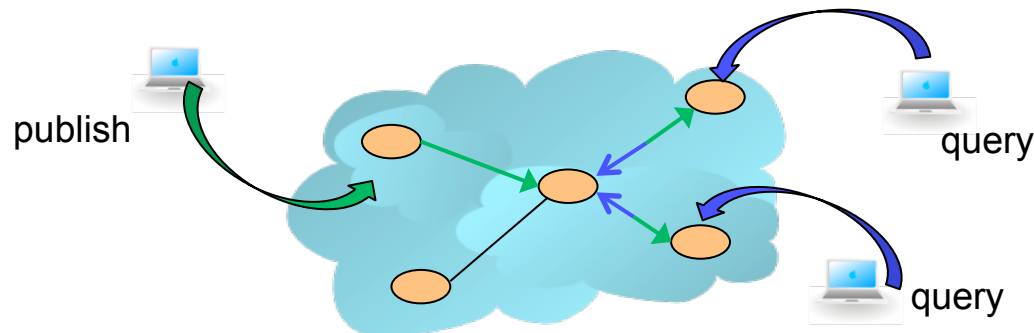
Problems with Today's Communication Networks

- 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

- 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

- 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
 - Whats a user's utility function like?
 - Response latency due to a disconnection probably dominates

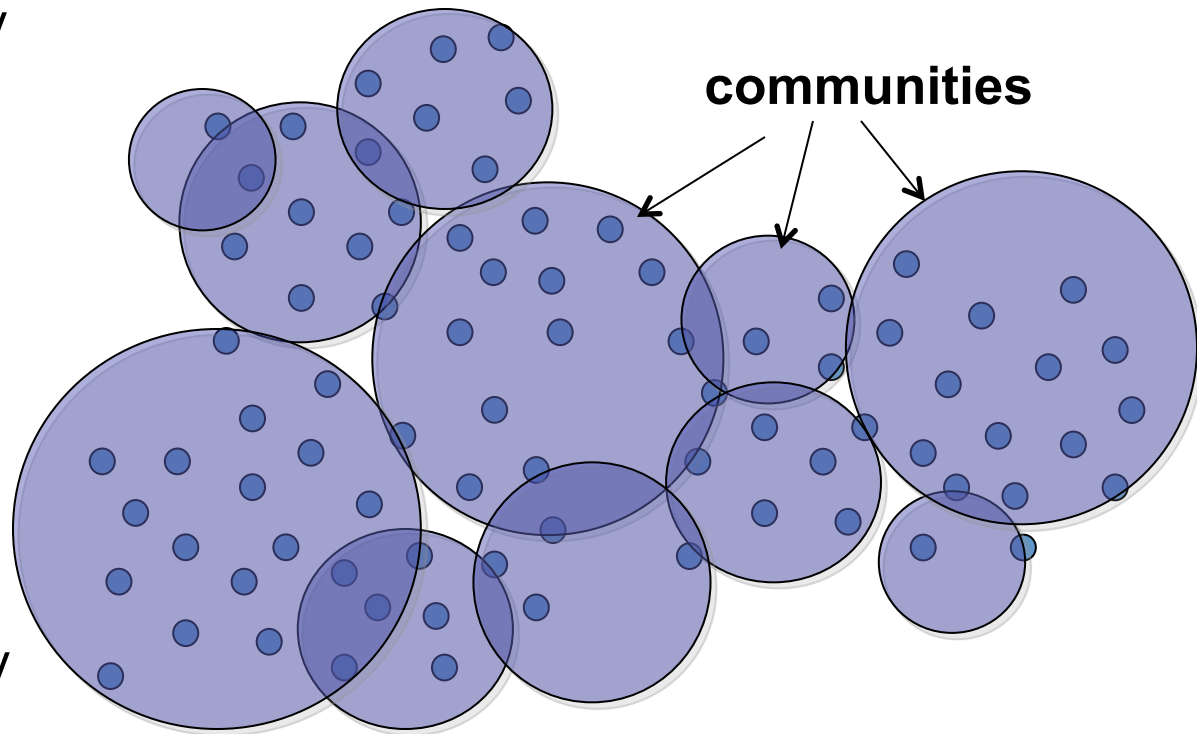
Slinky: A solution for MANETs and DTNs

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

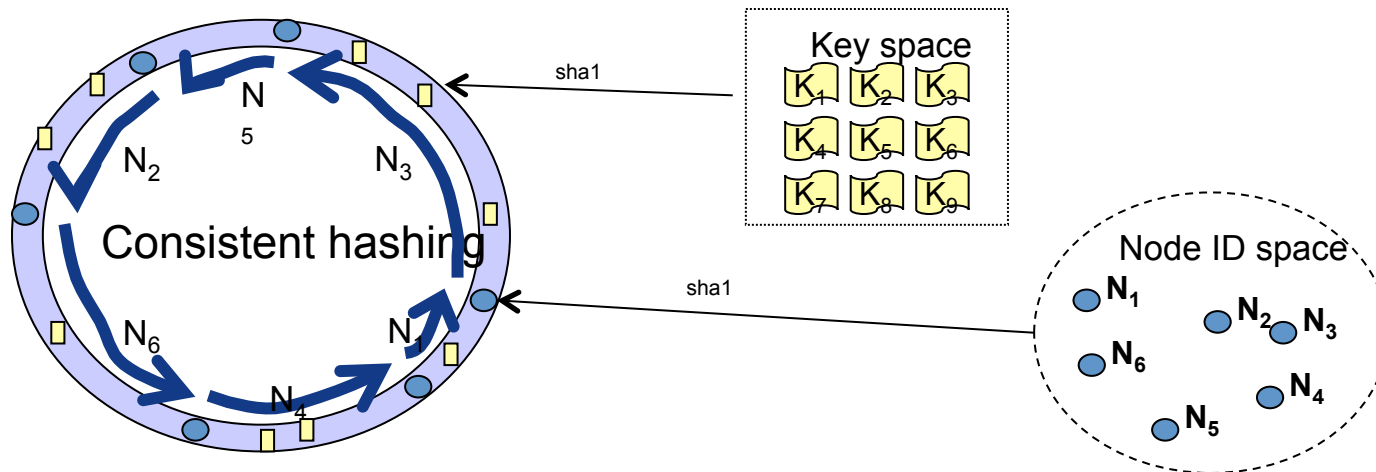
Communities reflect instantaneous structural information as well as temporal evolution of the network

Communities co-operatively store content of interest

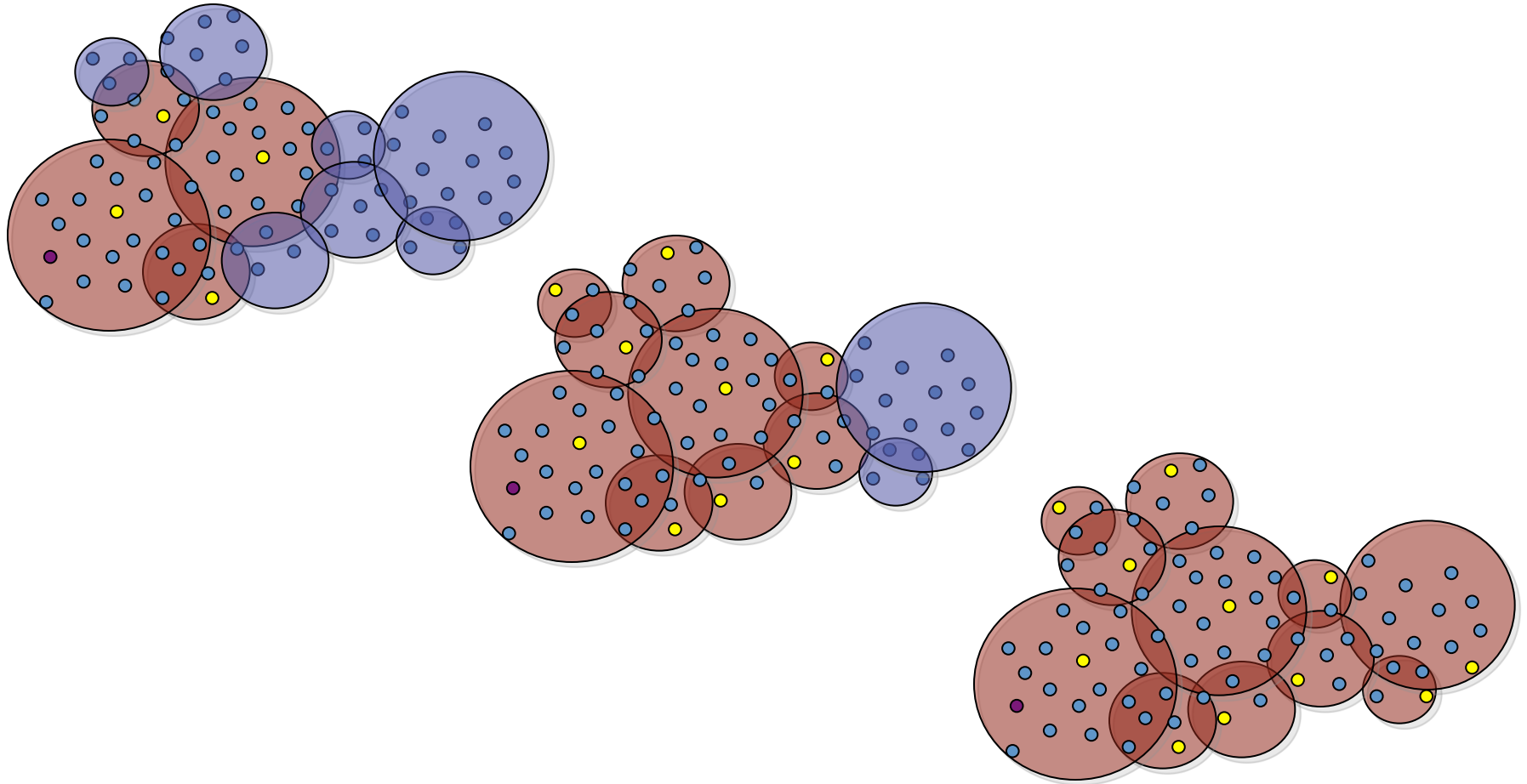


Consistent hashing based storage within a community

- 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
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- 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