Architectural Considerations for Mobile Mesh Networking

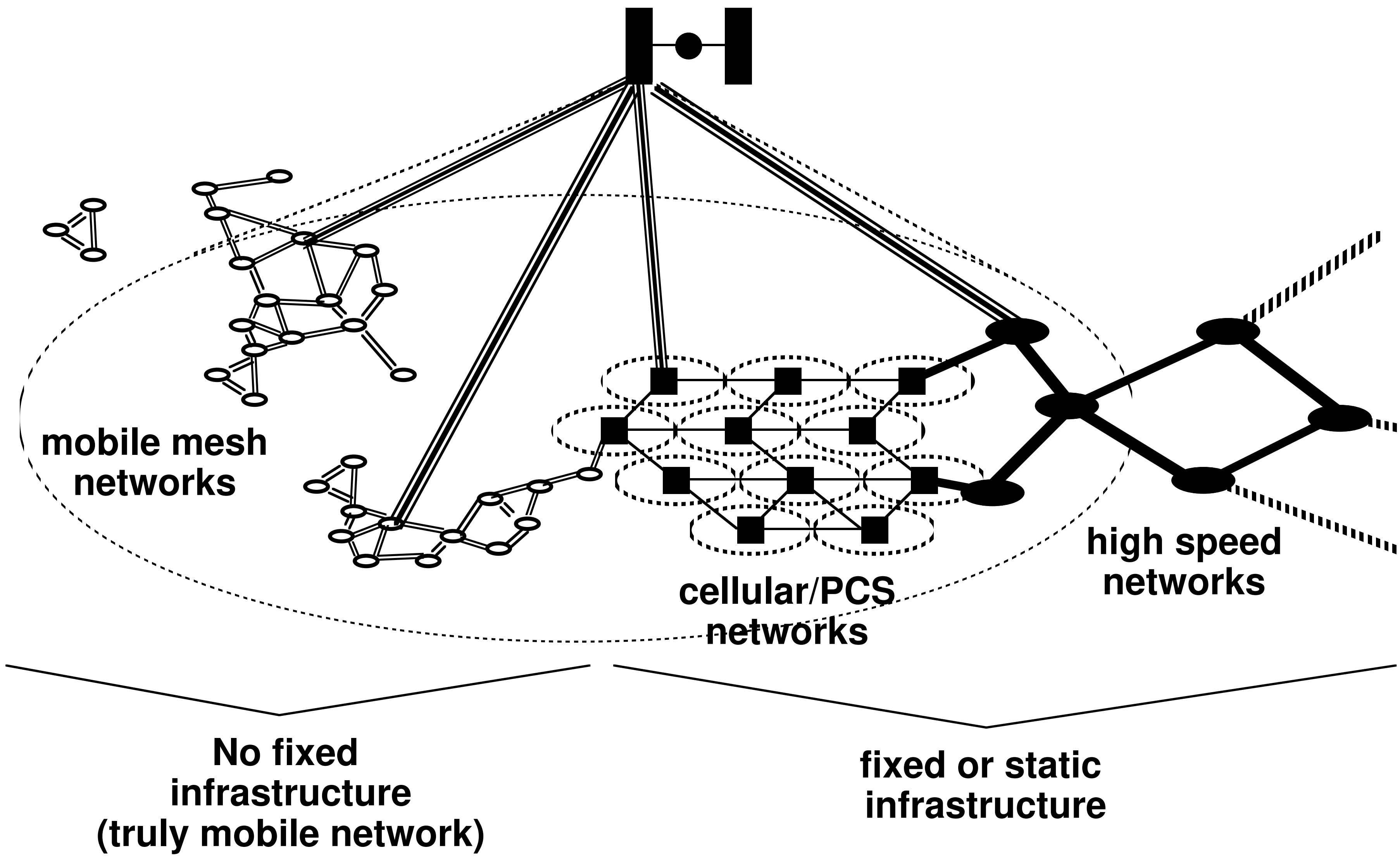
M. Scott Corson

University of Maryland

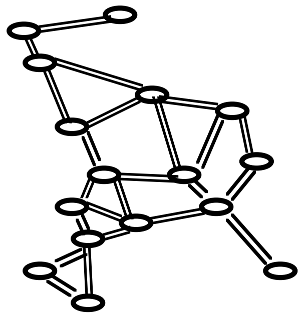
Steve Batsell **Joe Macker**

Naval Research Laboratory

Hybrid Communication Networks



Mobile Mesh Networks

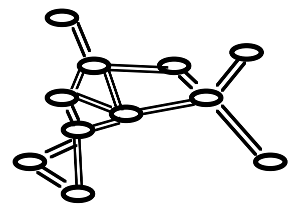


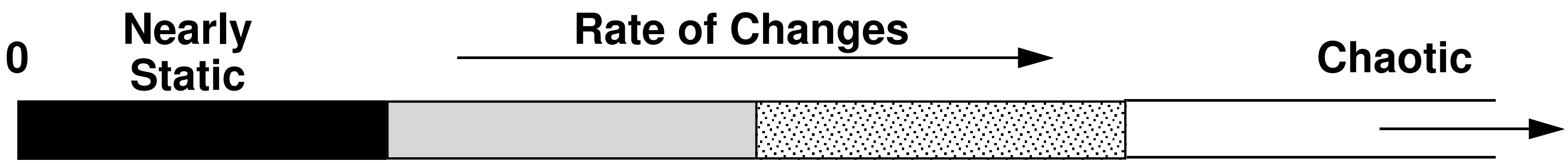
- **Mobile mesh networks consist of *mobile routers* which communicate with one another over *wireless links* using some combination of *broadcast* and *point-to-point* wireless technology**

Salient characteristics:

- **dynamic (sometimes rapidly changing) network topology**
- **bandwidth-constrained (congested) network operation**

Routing in a Rapidly Changing Topology





Nearly static approaches

– distributed Bellmann-Ford, optimal routing, quasi-static routing

Adaptive shortest-path algorithms

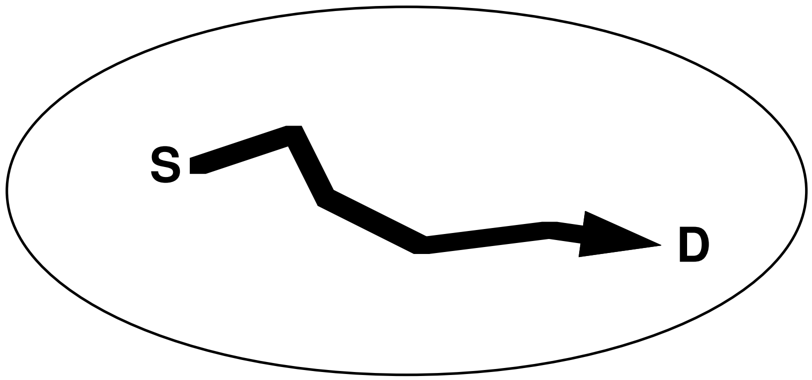
– link-state, path finding and loop-free distance vector approaches

Highly adaptive algorithms

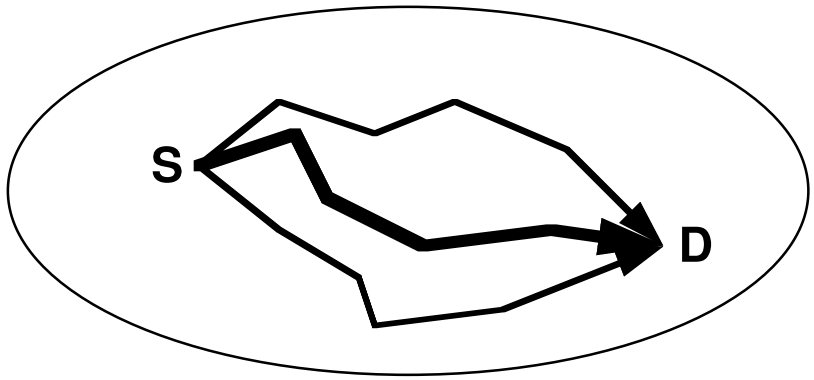
– Gafni-Bertsekas, Corson-Ephremides

Flooding algorithms

Routing in a Congested Network



Light Traffic: Shortest-path Routing



Heavy Traffic: Multipath Routing

- **A fundamental result of optimal routing theory states that**

  "under light traffic conditions, use the shortest available route; however, as traffic increases, offload some traffic to alternate routes to minimize delay"

Multipath **routing is required for efficient operation in a congested networks whether one is supporting connectionless or connection-oriented services**

Efficient Design for Congested Networks

- **Scarce bandwidth -> protocol *overhead* must be *minimized***
- **De-emphasize use of timer-based refresh mechanisms**
  - **Use soft-state with *very long* time-outs, only to guard against undetectable and unpreventable error occurrences.**
  - **End-to-end timer-based messaging is very *infrequent* , only to verify the existence of valid state**
- **Emphasize use of topologically-driven, event-based mechanisms**
  - **Assume existence of *frequent* link-level status sensing using timer-based messaging mechanisms (common in mobile systems)**
  - **Upper layer protocols react to link status change events signaled from link layer in an event-driven fashion**
  - **Event-driven mechanisms responsible for state *instantiation* and *clean-up***

Broad Design Assumptions

- ***Flat*** **routing scheme (intradomain)**
  - **very large networks require *hierarchical* approach between domains**
- ***Decoupling*** **of routing and multiple access permits operation across various multiple access techniques and architectures**
  - **for best performance, the processes of routing and multiple access should be *integrated;* thus, an *extended interface* should be provided to the link layer when integration is desired**
- ***Multiple*** **good routes are preferable to a *single* shortest-path route in a congested network and may be maintained with less overhead expended per route**
  - **permits randomized routing for connectionless traffic**
  - **permits multipath route selection for connection-oriented QoS-based traffic**
- **Build multipath routes *quickly* and *efficiently*, react to changes and quickly reestablish routes (if possible)**
  - **Optimality of routes is of secondary importance**
- ***Flooding*****, due to its bandwidth inefficiency, should only be used in extremely volatile topologies**

Motivation for Working Group

Motivations:

- **Military communications systems wish to use Internet technology when possible**
- **Commercial mobile mesh networking...**
  - **mobile automotive networks**
  - **wearable computing**
  - **fire, safety and rescue operations**

while still in its infancy, will also require an Internet solution to be interoperable with the fixed infrastructure Internet

Problem:

- **Some Internet protocols are not well suited for operation in mobile, bandwidth-constrained systems - they simply were not designed to work effectively in these environments**

Standard Internet Intradomain Routing Protocols

- **RIP - a distributed Bellmann-Ford implementation**
  - suffers from well-known looping and "counting-to-infinity" problems
  - does not support multipath routing
- **OSPF - a link-state implementation**
  - supports equal-cost multipath and can be configured to support more general forms of multipath routing
  - however, relies on *flooding* to maintain accurate topological knowledge at all routers which creates large amounts of overhead traffic

Potential Goals of Working Group

- **Develop efficient routing protocols to support unicast and multicast delivery**
  - **should include an optional flooding mode**
- **Define an extended interface to the multiple access sublayer to facilitate integration of routing and multiple access in some systems**
- **Define an extended interface to the transport layer to facilitate interaction with a resource reservation protocol**