**Introduction**

Intermittently connected mobile networks (ICMN) are sparse wireless networks where the connections between nodes are rarely exist or it is highly unstable and may break soon after it has been discovered this situation happens due to nodes mobility

**History**

In the 1970s, spurred by the decreasing size of computers, researchers began developing technology for routing between non-fixed locations of computers. While the field of ad hoc routing was inactive throughout the 1980s, the widespread use of wireless protocols reinvigorated the field in the 1990s as mobile ad hoc networking (MANET) and vehicular ad hoc networking became areas of increasing interest.

Concurrently with (but separate from) the MANET activities, DARPA had funded NASA, MITRE and others to develop a proposal for the Interplanetary Internet (IPN). Internet pioneer Vint Cerf and others developed the initial IPN architecture, relating to the necessity of networking technologies that can cope with the significant delays and packet corruption of deep-space communications. In 2002, Kevin Fall started to adapt some of the ideas in the IPN design to terrestrial networks and coined the term *delay-tolerant networking* and the DTN acronym. A paper published in 2003 SIGCOMM conference gives the motivation for DTNs, The mid-2000s brought about increased interest in DTNs, including a growing number of academic conferences on delay and disruption-tolerant networking, and growing interest in combining work from sensor networks and MANETs with the work on DTN. This field saw many optimizations on classic ad hoc and delay-tolerant networking algorithms and began to examine factors such as security, reliability, verifiability, and other areas of research that are well understood in traditional computer networking.

<https://en.wikipedia.org/wiki/Delay-tolerant_networking>

**Model of schemes**

**Single-copy**

Routing techniques that hand over a single copy from transmitter to receiver under special circumstances, calculation and analyzation but it take a huge delay and has a small chance of reaching the destination

**A. Direct Transmission**.

The sender node need to meet the receiver node to deliver the message, it may take long time to reach or may never reach the destination.

**B. Randomized Routing Algorithm**

### In this routing scheme the sender can use other nodes to deliver the massage, based on random algorithm.

### C. Utility-based Routing

Position information regarding different nodes gets indirectly logged in the last encounter timers, and gets diffused in the network though the mobility process of other nodes. This position information is not absolute, but rather relative to the position of another node. If a node is seen at some time instant having a low timer value for another node, then this other node is expected to be somewhere nearby

### D. The Seek and Focus Routing Protocol - a Hybrid Approach

It combines the randomized routing protocol case and utility-based routing protocols to have a faster transmissions from the randomized routing protocol and higher efficiency of utility-based routing protocols

**Multiple-copy**

It’s a routing technique that generate multiple copies of the same packet and route it to multiple paths to increase the possibility of reaching the destination. From that it may consume a high bandwidth that reduce the network efficiency.

1. **Epidemic routing:**

Its scheme that make the nodes replicate the packets and transmit it to the other nodes continuously in epidemic manner, however even if the packet reach it destination it won’t stop from spreading in the network.

1. **Spray and wait:**

The sender node will send the packet to particular number of nodes and they will use the direct transmission scheme to transmit the packet.

1. **Spray and focus:**

Generate and distribute a small and fixed number of copies to the same number of nodes. However, when a node has only one copy then transmit its copy further using a single-copy Seek and Focus scheme

1. **BAYESIAN ROUTING FRAMEWORK:**

This scheme has two stages: 1) classification 2) packet forwarding. The objective of the classification is to build classes that contains prior information of nodes about the networks. In the packet forwarding, it will send packets to the node have better affinity with the destination that stored on the classes from previous stage (classification).

1. **Bubble rap:**

Every node has an abstract label that informs its affiliation to other nodes so the nodes who have the same affiliation, they will be selected and it will put on same label as the destination. It shows that the LABEL improves efficiency of packet forwarding

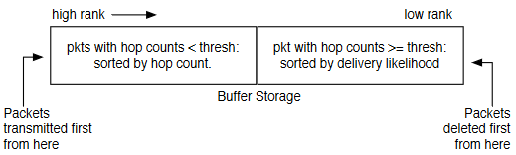
1. **PRoPHET:**

it sends the packet depend on the probability of encounter history.

if the sender met other node check for the probabilities, if its probability of meeting the destination more than the probability of the sender then the sender will give a copy of the packet, if its less then it won’t send a copy.

1. [**MaxProp**](https://en.wikipedia.org/wiki/Routing_in_delay-tolerant_networking#MaxProp)**:**

It behaves like flooding based protocol when starting sending pakets, so every node will attempt to transfer and replicate all messages. But it use some mechanisms to determine which messages are transmitted and deleted first by estimation the delivery likelihood for every message



<https://kdl.cs.umass.edu/papers/jensen-et-al-infocom2006.pdf>

**Things that will affect the performance of DTN communication:**

* Number of nodes (more nodes means more probability to reach the destination) in same way if we increase number of the nodes that will make more congestion will effect for the speed of delivering data.
* Area of coverage (large area means less congestion) also large area means data take long time to reach the destination.
* Mobility of nodes (high mobility means high congestion)
* Schema used (depends on which technique which strategy you want to use)
* Packet size (large packet will need more time to transmit it) need more buffers, increases cost.

**Why ICMN?**

As the node’s mobility and energy are limited we can use this technology to deliver the messages depends on the distance and the paths for each packet there are many applications can handle with ICMN

It very useful at certain conditions

**Applications:**

* **Military uses**
* Monitoring and tracking the allies forces
* send estimated damages to HQ
* communications
* **Wildlife monitoring**
* Study the behavior and the movement of animals to save them from extinction
* **Emergency**
* If there is a disaster in some countries all communications systems shut down, they can send SOS massages to emergency unit.
* **Satellites for share data**
* When the satellite had attenuation or disruption due to the long distance and interference of the sun radiations it can’t deliver the information to earth base, then the satellite depends to other satellite for sending the data until reach the destination.

**Which is better?**

|  |  |  |  |
| --- | --- | --- | --- |
| Schemes | Model | Advantage | Disadvantage |
| Direct Transmission | **Single-copy** | **Reliability.** | **The sender most meet the receiver, take too much time.** |
| Randomized Routing Algorithm | **Single-copy** | **It can escape from loop.** | **Its random process maybe not arrive to the destination.** |
| Utility-based Routing | **Single-copy** | **More possible to reach the target.** | **Stuck in endless loop.** |
| Seek and Focus | **Single-copy** | **It has advantages of Randomized and Utility-based Routing.** | **Has only one copy** |
| Epidemic | **Multiple-copy** | **Has a large covering area.** | **Make a traffic.** |
| Spray and wait | **Multiple-copy** | **Control the number of packets.** |  |
| [MaxProp](https://en.wikipedia.org/wiki/Routing_in_delay-tolerant_networking#MaxProp) | **Multiple-copy** |  |  |
| PRoPHET | **Multiple-copy** |  |  |
| Bubble rap | **Multiple-copy** |  |  |
| BAYESIAN ROUTING FRAMEWORK | **Multiple-copy** |  |  |