Routing Metrics

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We will now be looking into the different kinds of metrics that are used to measure the performance of both individual links and of the network as a whole. Using **routing metrics** involves assigning a value to each route or path that indicates the extent of how good or bad that route is. These values are in turn used by routing algorithms to select one or more routes.

The values reflect the cost of using that route with respect to some optimization objective. There can be different objectives and thus different metrics. One of the most commonly used metrics is **hop count**.

## Optimization Objectives

* Minimize delay
* Maximize probability of data delivery
* Maximize path throughput
* Maximize network throughput
* Minimize energy consumption
* Equally distribute traffic load

## Challenges in Wireless Networks

Which optimization objective we should concentrate on is dictated by a few aspects of wireless networks:

* **Node Mobility** – We need to keep in mind that frequently, the nodes in wireless networks are mobile.
* **Wireless Medium** – The very fact that the medium is wireless introduces challenges with regards to speed, data corruption, etc. For example, for wired networks it is nearly guaranteed that the data will be transmitted successfully, but for wireless networks, this is not true.
* **Energy Constraints** – Wireless nodes are frequently battery powered.
* **No Centralized Control** – Wireless networks also sometimes have no centralized controller, which has an effect on the choice of optimization parameter.

## ETX

**Expected Transmission Count** (ETX) is a routing metric which measure the **number of transmissions** required to make a successful delivery between two nodes. The objective is to **minimize** this value.

The link ETX can also be used to calculate the throughput.

There are various ways in which the ETX value is calculated. In IEEE 802.11, this is calculated based on the probability of successful delivery of both data and ACK packets.

These equations are theoretical. In real life, we use **forward** and **reverse delivery ratios**, i.e. is the forward delivery ratio and is the reverse delivery ratio.

### Measuring Delivery Ratios

To measure the forward and reverse delivery ratios, each node broadcasts small **link probes**, which are of 134 bytes, once per second. A node can remember these link probe packets for up to 10 seconds. Both the forward and reverse delivery ratios are calculated using these link probes.

The **forward delivery ratio** is the probability of successfully sending a packet to the receiver. The sender already knows how many packets it sent out in the last 10 seconds. However, it does not know how many of those packets the receiver received. ACKs are not an appropriate way to calculate this, since it is entirely possible that some ACKs are lost. Instead, the receiver, which is also sending link probes for its own measurements, piggybacks this information (i.e. how many packets it received in the last 10 seconds).

This value is constantly updated using that 10 second window.

The **reverse delivery ratio** measures the probability of successfully getting an ACK. This is simpler, since it is just the ratio of how many ACKs were received compared to the total number of packets sent.

### Route ETX

The **Route ETX** is just the sum of all the link ETX values in the route.

### Limitations

There are several issues with the ETX metric.

Firstly, we need to consider **network congestion**. We are broadcasting link probes, which means it is entirely possible for there to be collisions, which we are not accounting for. Other issues like hidden terminals interfering with broadcasts can also cause the measurements to be unfair.

Secondly, the ETX estimates are based on a 134 byte link probe. Actual data packets are usually larger while ACK packets are smaller. This causes an **underestimation** of **data loss ratios** and an **overestimation** of **ACK loss ratios**.

Thirdly, we ignore how long each transmission takes, which means we are assuming that all the links have the **same bitrate**.

To deal with these issues, we have the ETT metric.

## ETT

**Expected Transmission Time** (ETT) incorporates **throughput** into its calculation.

Here, is the size of the link probe packet and is the measured bandwidth of the link.