Network Design and Optimization course

Lecture 2

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The problem

Given

- an existing network,
- a connection request between two nodes of the network,

I want to

- decide which links to use in the connection (route)
- maximizing the quality of service (e.g. minimizing power loss)

Assumptions

Some assumptions:

1. all packets must be routed on the same links,
2. the capacity of each link is enough for the whole connection request.

N.B. imposing (1), or assuming that link usage cost does not depend on the amount of traffic routed is the same.

Recognizing a known problem ...

We are facing a *Shortest path problem*!

Modeling the costs

Step 1: estimating link usage costs. How?

- Know your network;
- make suitable assumptions and simplifications!

Example 2: routing on networks having power losses

Let's assume to have a network with radio links:

- packets are datagrams,
- a network designer can disregard link capacities,
- network congestion may not be the main can cause of packet loss ...

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Example 2: routing on networks having power losses

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- packets are datagrams,
- a network designer can disregard link capacities,
- network congestion may not be the main can cause of packet loss ...
- **indeed, signals lose power while being transmitted on links (attenuation), ...**
- **... however, signal power can be restored at nodes**

Line attenuation do happens (WiFi, DLS ...)!.

Example 2: routing on networks having power losses

It is appropriate to minimize overall power loss ...

- Let's denote as $c(e)$ the power loss (in dB) on each link e of the network
- ... the overall power loss of a packet routed on links $(e(1) \ldots e(n))$ is $\sum_{i=1}^{n} c_{e(i)}$
- ... (e.g. realistic while transmitting on coaxial cables).

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- ... the overall power loss of a packet routed on links $(e(1) \dots e(n))$ is $\sum_{i=1}^{n} c_{e(i)}$
- ... (e.g. realistic while transmitting on coaxial cables).
- Let's denote as $g(v)$ the power gain (in dB) on each node v of the network
- ... the overall power loss/gain of a packet routed on links $(e(1) \dots e(n))$ and through nodes $(v(1) \dots v(n+1))$ is $\sum_{i=1}^{n} c_{e(i)} + \sum_{i=1}^{n+1} g_{v(i)}$

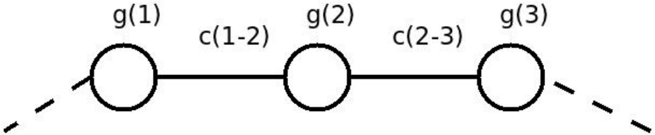
Network model

Given a network, build a graph $G = (V, E)$ having

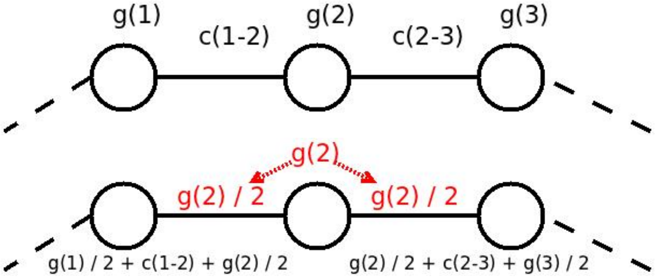
- one vertex $i \in V$ for each node of the network
- one edge $e \in E$ for each link of the network
- costs c_e on each arc $e \in E$
- prizes g_v on each node $v \in V$
- a special vertex $s \in V$ representing the origin of packets
- a special vertex $t \in V$ representing the destination of packets

And solve ... what?

Network model



Network model



Can we still use Dijkstra?

Label Correcting algorithm

See Orlin's slides

Label Correcting correctness proof

See Orlin's slides

Label Correcting algorithm implementation

Let's implement the Label Correcting Algorithm in AMPL ...