Dynamics of ATM Networks

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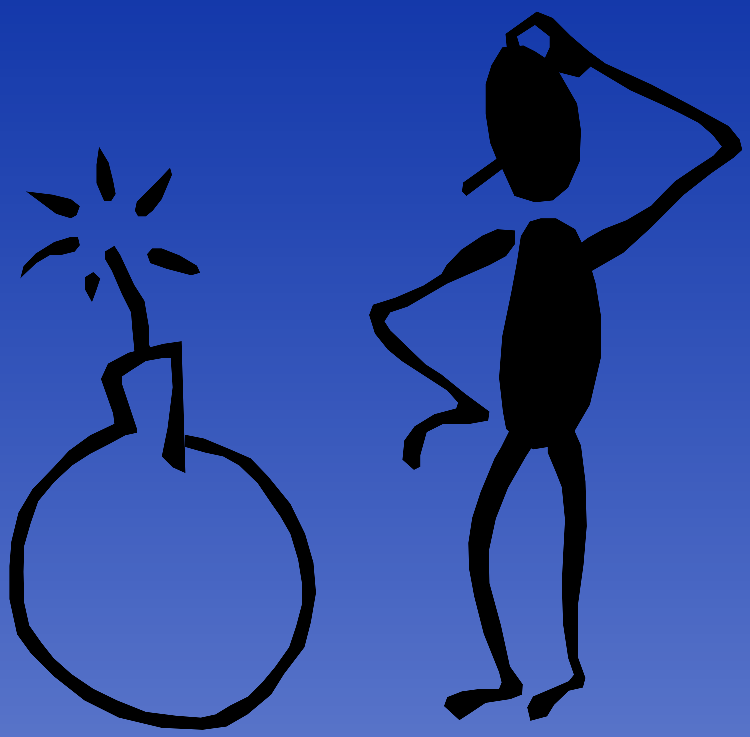
Dynamics of ATM Networks

Bandwidth management and traffic routing on arbitrarily scaleable multi-traffic-type ATM networks

The problem

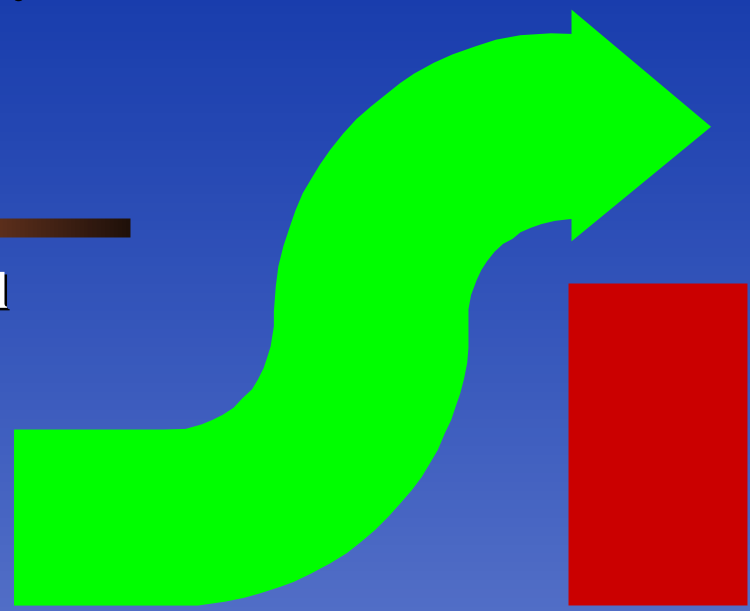


- Multimedia traffic always expands to fill the bandwidth available
  - For instance: today's Internet
- This results in long and highly variable delays
  - Many buffers between traffic source and destination
- What about delay sensitive or otherwise urgent traffic?

The problem: A solution?

- Delay sensitive and urgent traffic must be guaranteed fixed delay
  - Constant or variable bitrate
  - Even when mixed with low urgency traffic

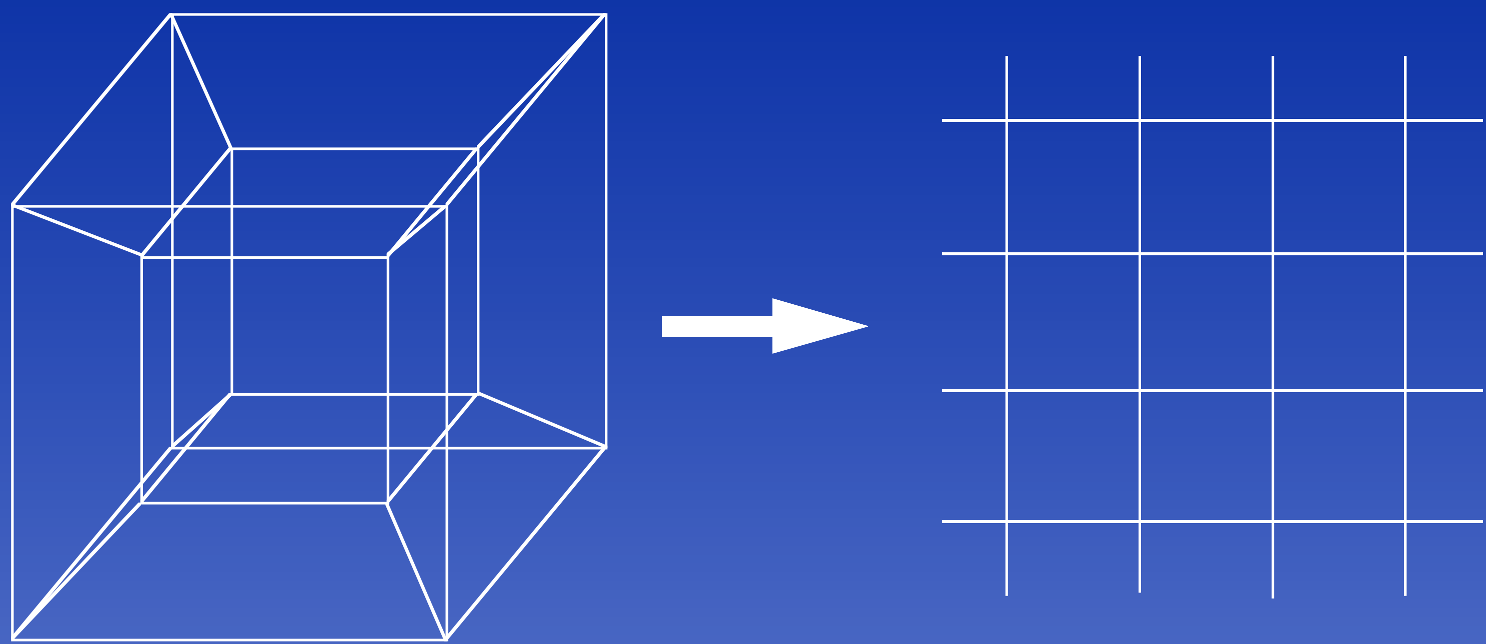
- Super-symmetric hierarchical core network
- Dynamic pricing
- Routing strategy



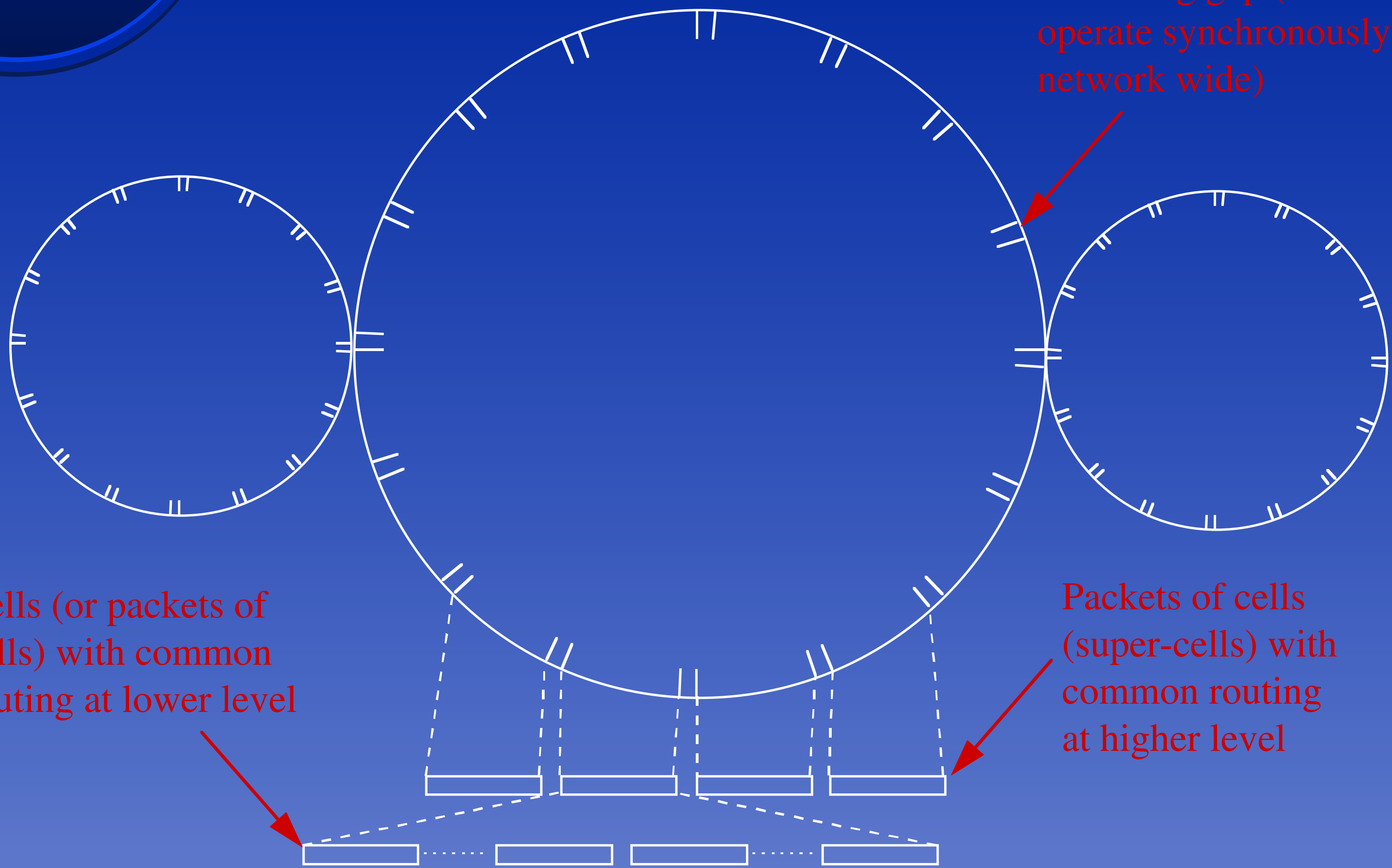
Network symmetry

- **Super-symmetric hierarchical network structure**
  - **Nodes equidistant**
    - **Routing choices**
    - **Uniform internodal delay**
  - **“Super-cells”**
    - **Reduced switching rate**
    - **ATM routing reduced to time-division-multiplexing within each tier**

A symmetric network



Hierarchy


Switching gap (switches operate synchronously network wide)
Cells (or packets of cells) with common routing at lower level
Packets of cells (super-cells) with common routing at higher level

Dynamic pricing

- **Aim: design a system which**
  - **allows variable bandwidth**
  - **guarantees fixed delay**
  - **guarantees essentially zero cell loss probability**
- **Routes, links or resources are priced according to level of utilisation**
  - **More traffic $\Rightarrow$ higher cost per unit bandwidth**
  - **Higher cost $\Rightarrow$ reduction in users (or less use per user)**
- **Result: delay sensitive or high value data is given priority**

Dynamic pricing (ctd)

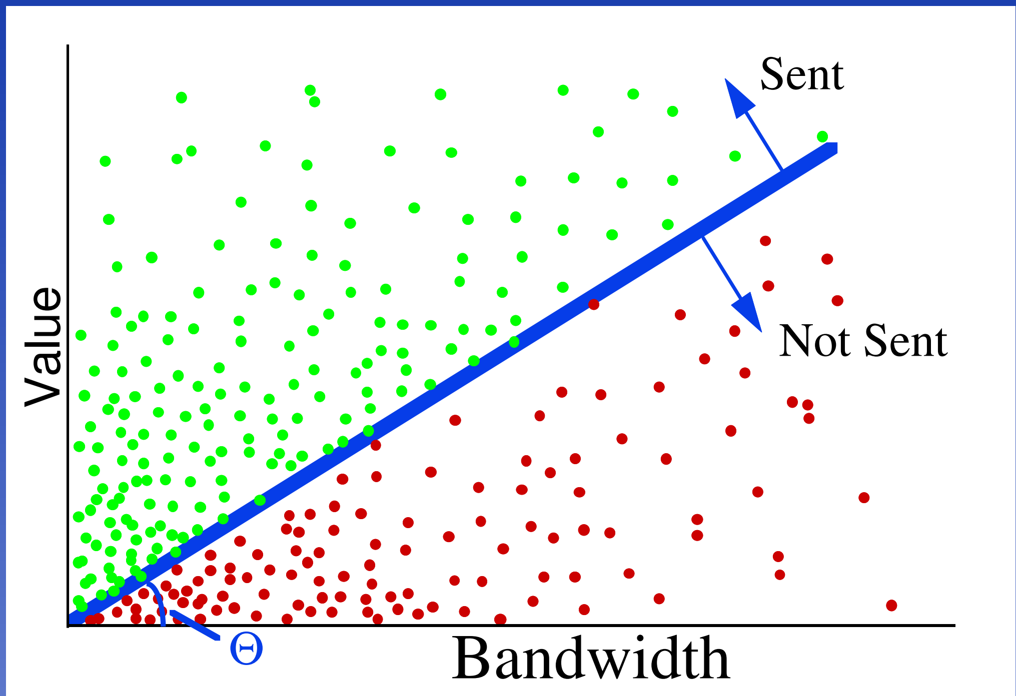
- **The bandwidths of a multitude of traffic streams are dynamically adjusted according to value**
- **Capacity overload is handled at the periphery of the network**
  - **Users are given a *choice* of how to pay for overloading the network**
    - **Pay by suffering delay**
    - **Pay by suffering cell loss**
    - **Pay real money**
  - **Current packet networks *impose* delay and loss - no third option is given**

Dynamic pricing (ctd)

- **"Discovery"**
  - **If bandwidth and value are assumed to be random with independent Gaussian distributions then:**
  - **Flow can be regulated under *any* degree of overload to give any *desired* level of resource utilisation and *maximum value transfer***
- **How?**
  - **Define a price of access, P**
    - **Traffic is only admitted if Value/Bandwidth $\geq P$**
  - **Price can also be considered as an angle, Θ:**
    - $\Theta = \tan^{-1}(P)$

Bandwidth and value

- Only those users who value their data sufficiently transmit it



Dynamic pricing (ctd)

- **The mean bandwidth over all users can be calculated as:**

$$\int_{v=0}^{\infty}\int_{b=0}^{\infty} b \cdot \mathrm{p}(bw = b) \cdot \mathrm{p}(val = v)\,db\,dv$$

or, equivalently

$$\int_{\theta=0}^{\pi/2}\int_{r=0}^{\infty} b \cdot \mathrm{p}(bw = b) \cdot \mathrm{p}(val = v)\,dr\,d\theta$$

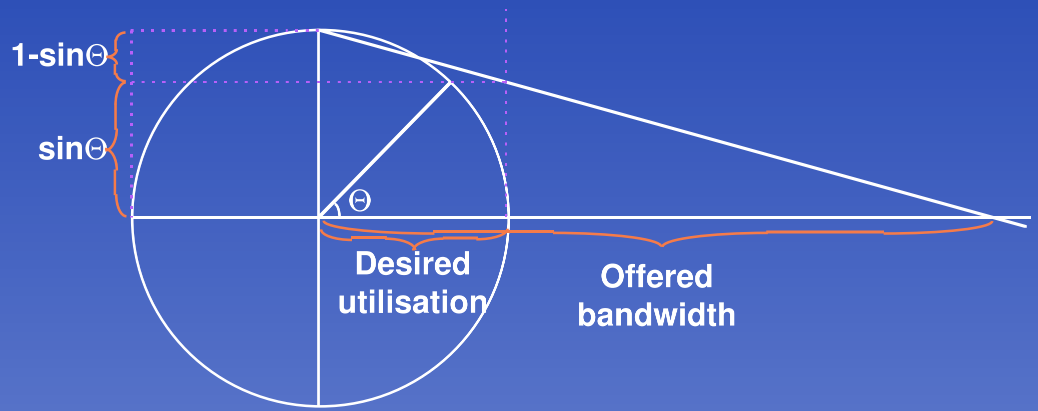
- **And so the mean bandwidth of those satisfying the price condition: Val/BW > $\tan^{-1}(\Theta)$ is:**

$$\int_{\theta=\Theta}^{\pi/2}\int_{r=0}^{\infty} b \cdot \mathrm{p}(bw = r\cos\theta) \cdot \mathrm{p}(val = r\sin\theta)\,dr\,d\theta$$

  - **when the equation is transformed into polar co-ordinates**

Dynamic pricing: conclusion

- With the assumptions on the distributions, the ratio between transmitted bandwidth (with price control) and offered bandwidth (no price control) can be calculated
  - $B_{tr}/B_{off} = 1-\sin\Theta$



Routing and optimisation

- **Given the choices available, how does the user or network operator select a route? Least cost routing**
  - **Resources priced according to fill: Price $\propto$ availability^{-1}**
  - **User's (or network operator's) software agent selects the route involving minimum total cost**
- **What is being optimised? Value throughput**
  - **Increasing utilisation $\Rightarrow$ increasing price**
  - **Low value users must**
    - **Decrease use**
    - **Increase willingness to pay**
- **Maximum *value* as well as volume of data handled**

Summary

- **Scaleable symmetric network design**
- **Buffers located at periphery**
- **Dynamic pricing**
- **Value throughput optimised**