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# **Flow aware Admission Control for a Commercially Viable Internet**

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# Requirements for the viability of a commercial network

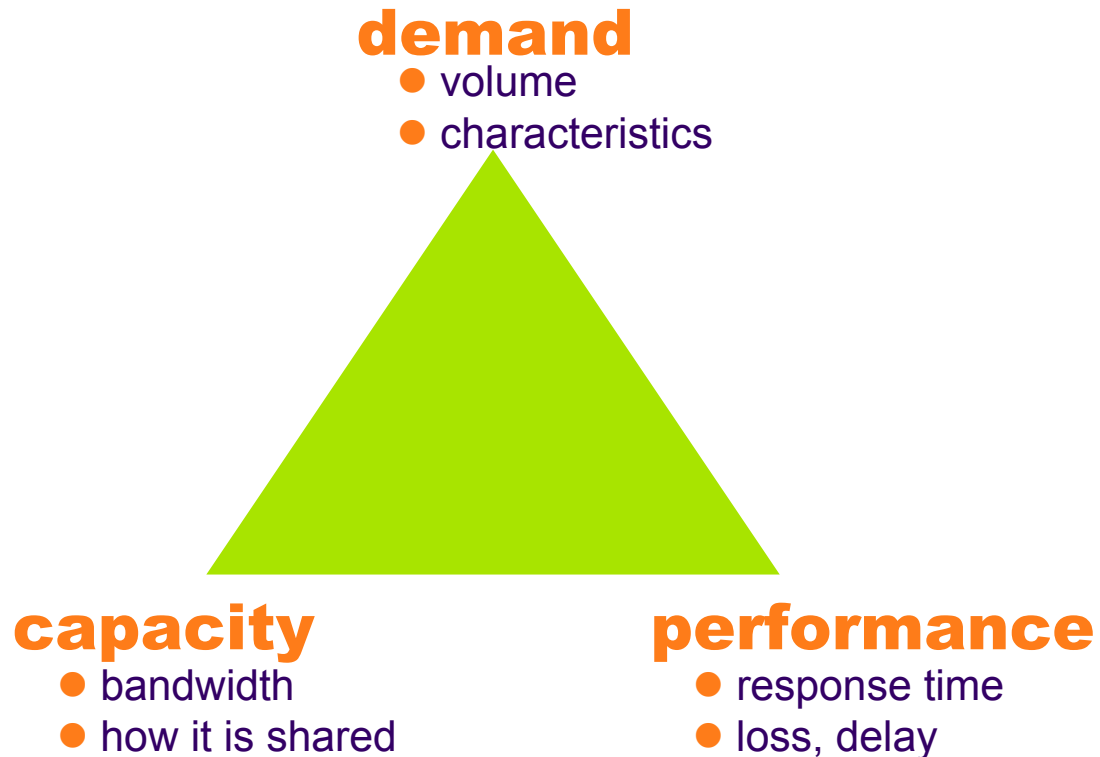


- we assume
  - ▶ a competitive environment
  - ▶ viability must derive from the sale of transport services (no cross-subsidy)
  
- a commercial network is viable if it federates a large customer base
  - ▶ high degree of sharing (individual demands  $\ll$  capacity)
  - ▶ assure adequate QoS economically - Technology is not the only consideration
  
- none of the currently proposed QoS models constitutes a cost-effective QoS solution
  - ▶ over-provisioning : simple and pragmatic engineering rule but not viable
  - ▶ Intserv, Diffserv : do not take sufficient account of the statistical nature of traffic

# QoS and the statistical nature of demand



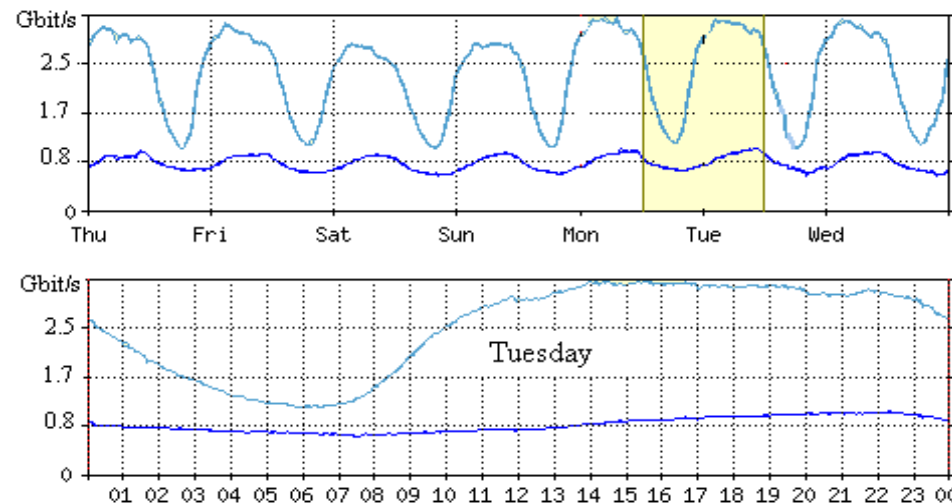
- assuring QoS relies on understanding the relationship between demand, capacity and performance



# IP traffic variations



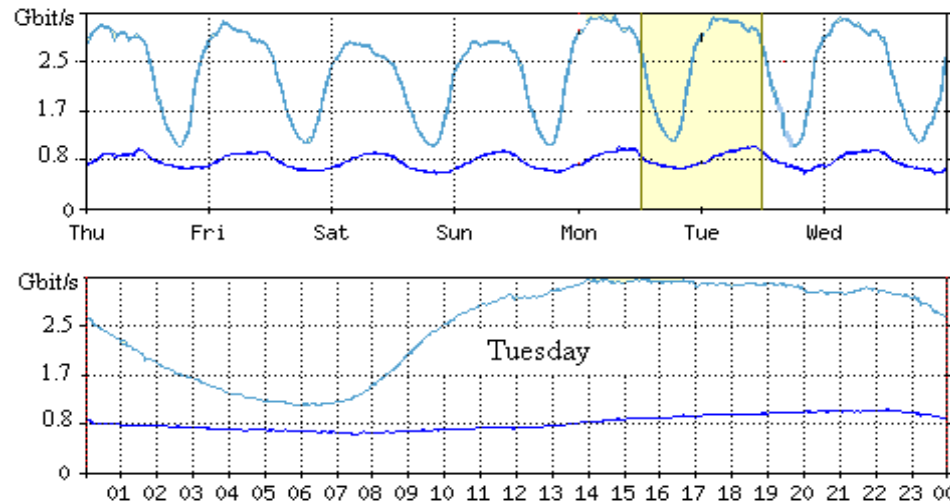
- traffic exhibits systematic day of week and time of day variations
- traffic is relatively stable in a wide busy period...
- ... with statistical variations about mean due to user activity



# IP traffic variations



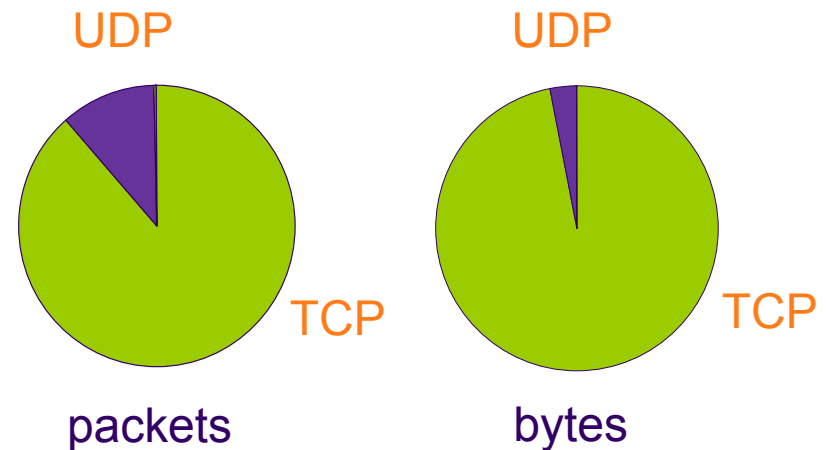
- traffic exhibits systematic day of week and time of day variations
- traffic is relatively stable in a wide busy period...
- ... with statistical variations about mean due to user activity
- a sizing objective:
  - ▶ enough capacity to meet QoS requirements (an "Erlang formula" for IP)...
  - ▶ ... with due allowance for overloads



# Composition of IP traffic



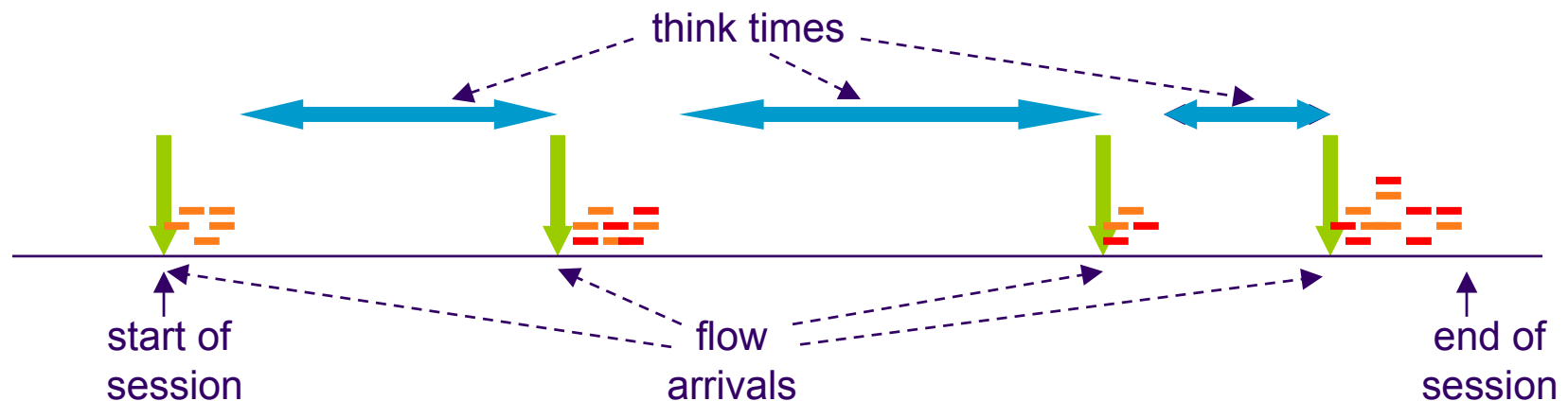
- by protocol:
  - ▶ TCP: 83% of packets, 91% of bytes
  - ▶ UDP: 14% of packets, 5% of bytes
- by application:
  - ▶ P2P, HTTP, ...
  - ▶ real audio, video, VoIP, ...
- a simple robust classification:
  - ▶ elastic traffic (>90%)
  - ▶ streaming traffic (<10%)
- most traffic is (still) elastic
  - ▶ more than 90%



# Packets, flows and sessions



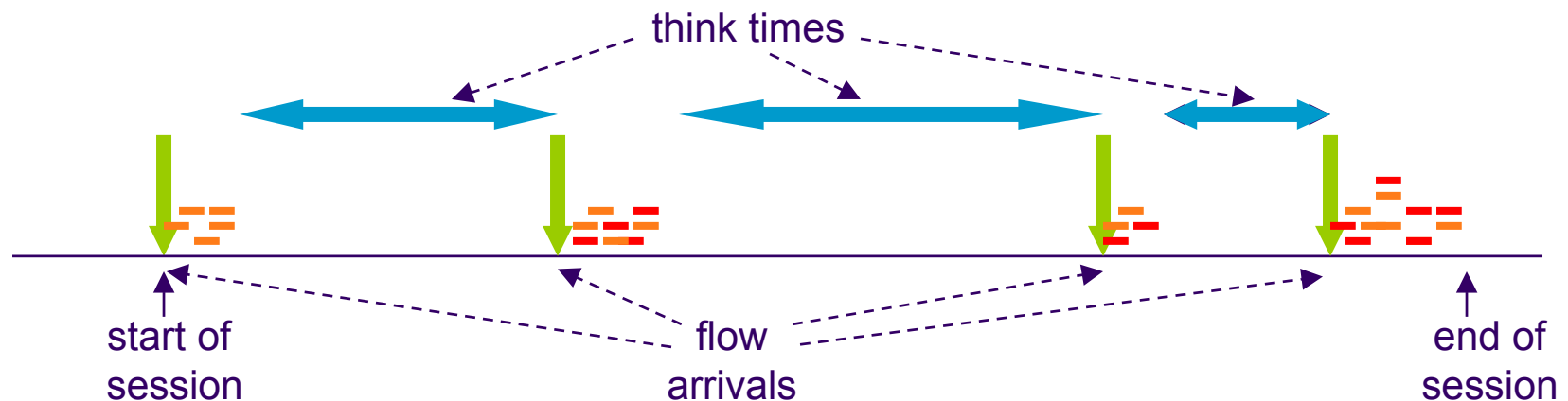
- packets are part of "flows"...
  - ▶ a flow: all packets corresponding to one instance of a given application...
  - ▶ ... having the same identifier and occurring within a short time
- ... flows are part of "sessions"
  - ▶ a succession of flows and "think times"
  - ▶ relating to some homogeneous user activity (e-commerce, mail,...)



# Packets, flows and sessions



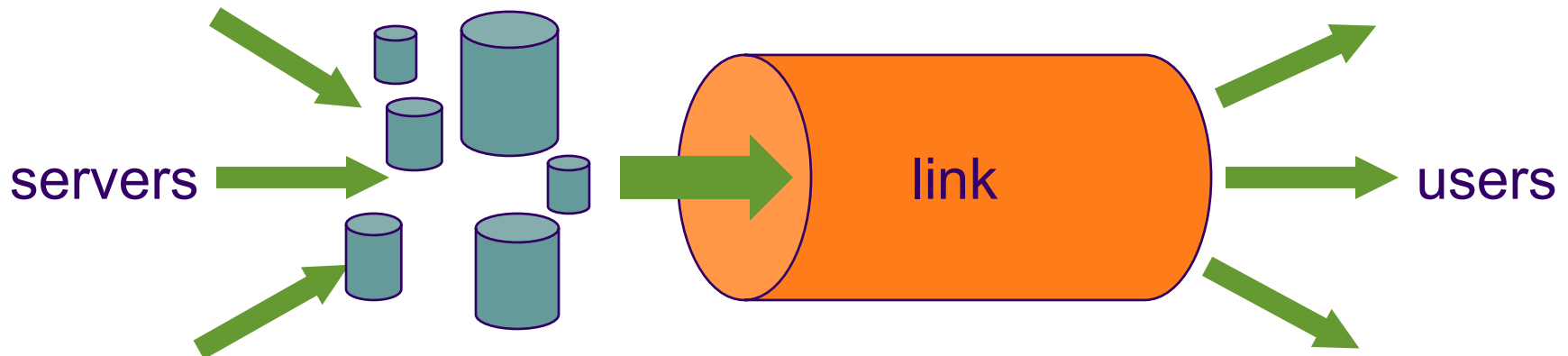
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- modelling assumption: sessions occur as a Poisson process
  - ▶ in the busy period (like telephone calls!)



# Performance model for elastic traffic



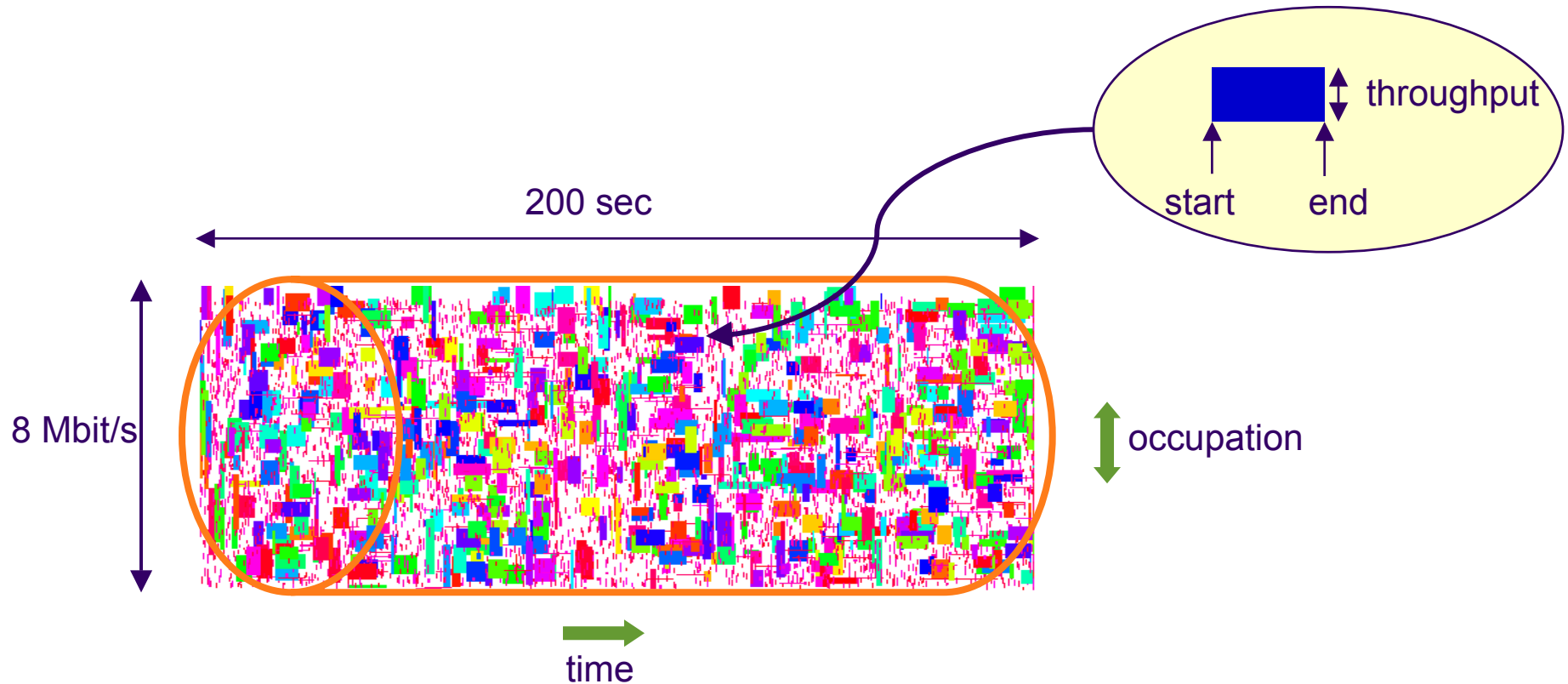
- TCP adjusts connection rates...
  - ▶ using the congestion avoidance algorithms
  - ▶ to (approximately fairly) share link bandwidth
- realized flow throughput depends on offered load
  - ▶ demand = arrival rate  $\times$  average size (bit/s)
  - ▶ throughput  $\approx$  capacity – demand (assuming fair sharing)





# Simulation results: capacity 8 Mbit/s, offered load 90%

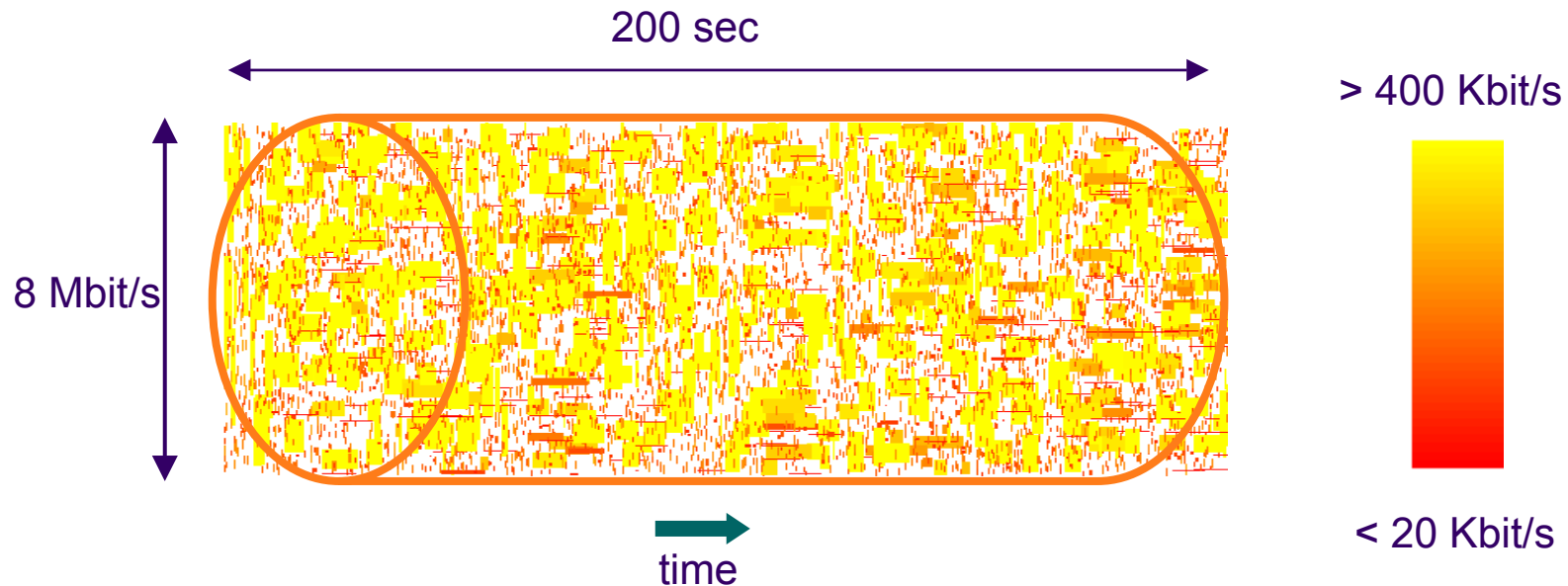
→ visualization of per flow throughput





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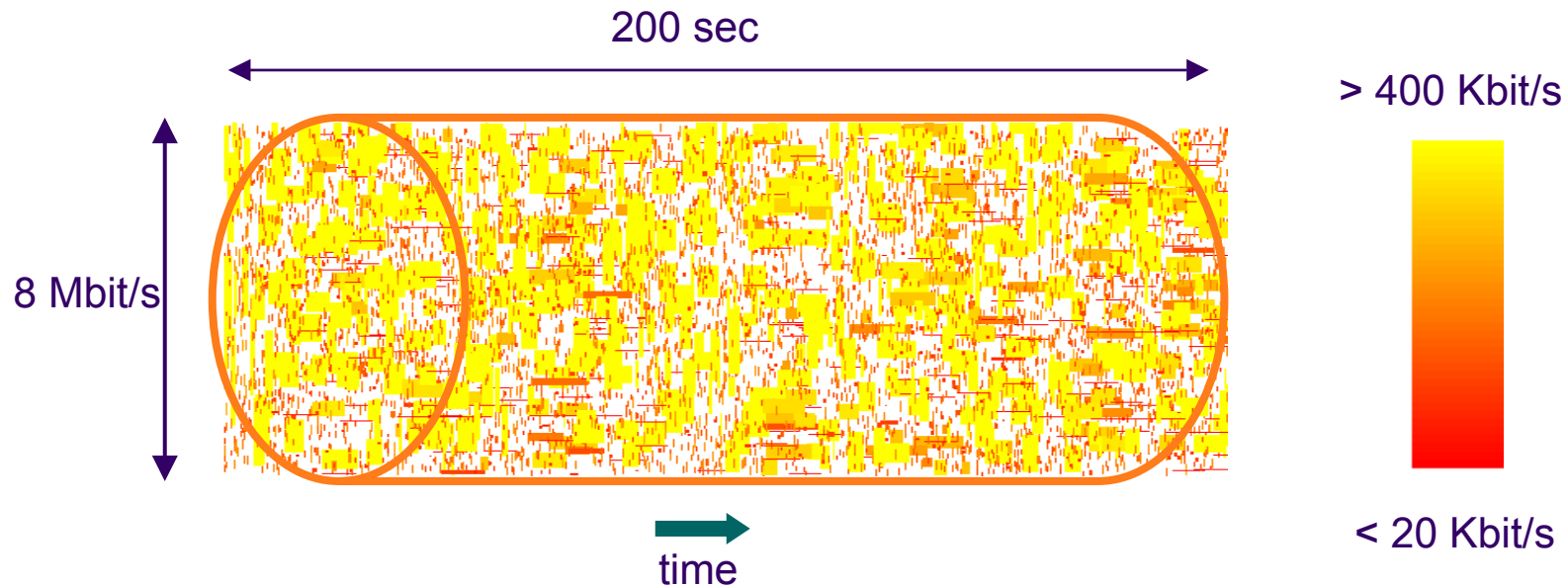
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# Simulation results: capacity 8 Mbit/s, offered load 90%

- visualization of per flow throughput
- the link is *transparent*, even at 90% utilization
  - ▶ throughput is determined by external limits
  - ▶ no scope for service differentiation

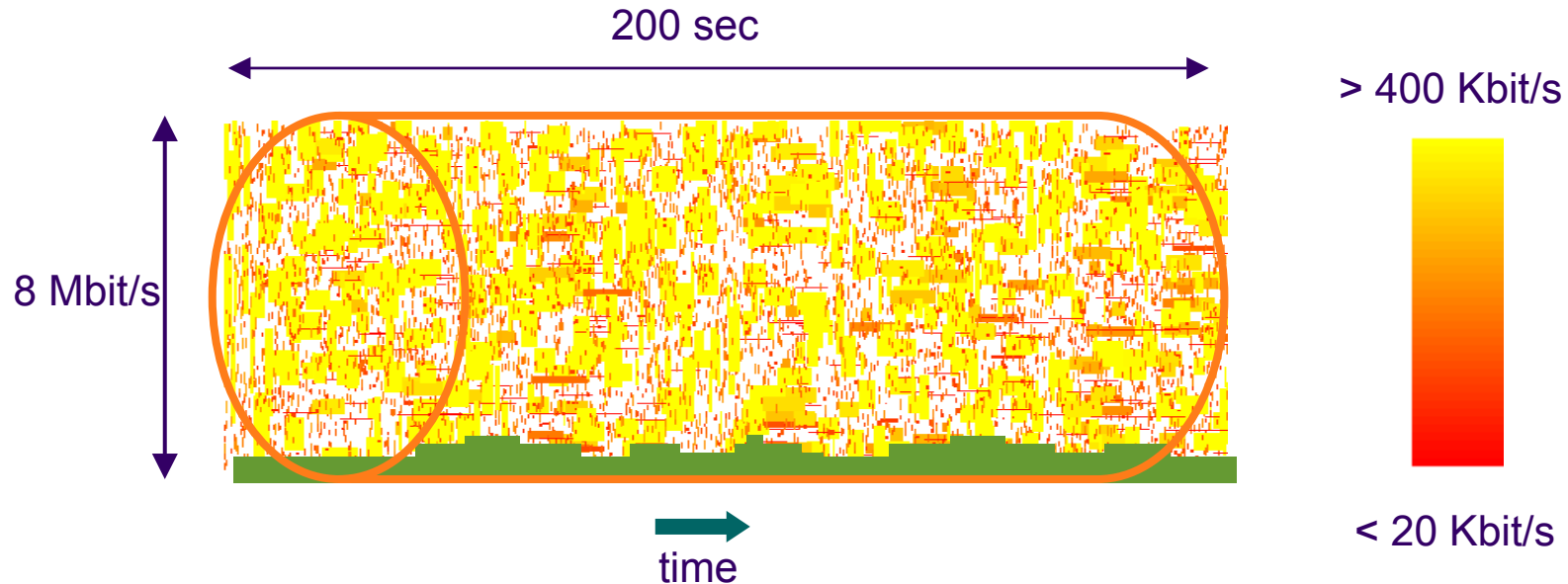




# Simulation results: capacity

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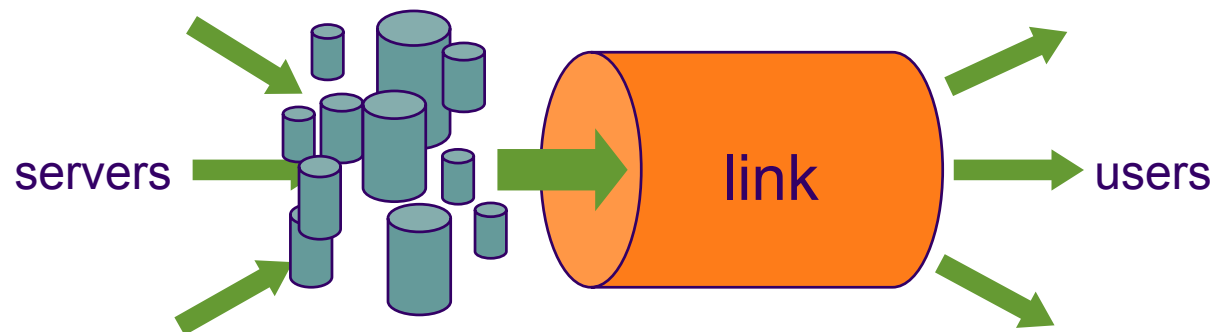
- visualization of per flow throughput
- the link is *transparent*, even at 90% utilization
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- transparency for streaming flows
  - ▶ give priority to streaming flow packets



# Impact of overload



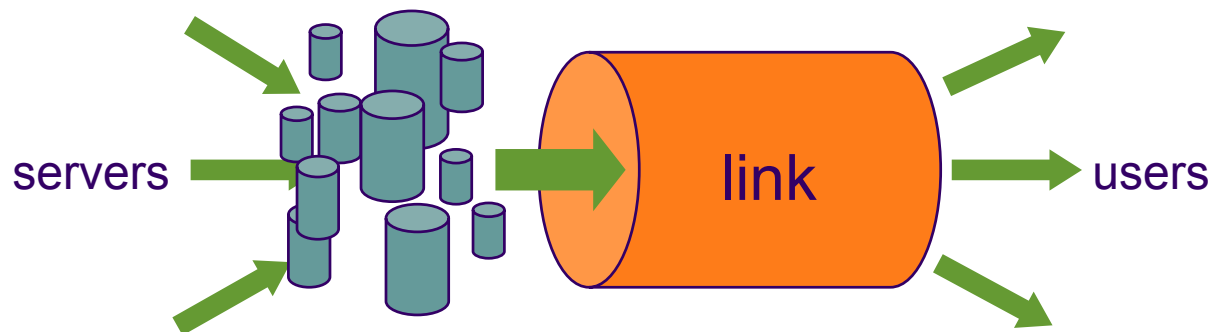
- overloads occur (when demand > capacity)
  - ▶ failures
  - ▶ forecasting errors
  - ▶ traffic surges
  - ▶ deliberate choice (eg, some peering links)



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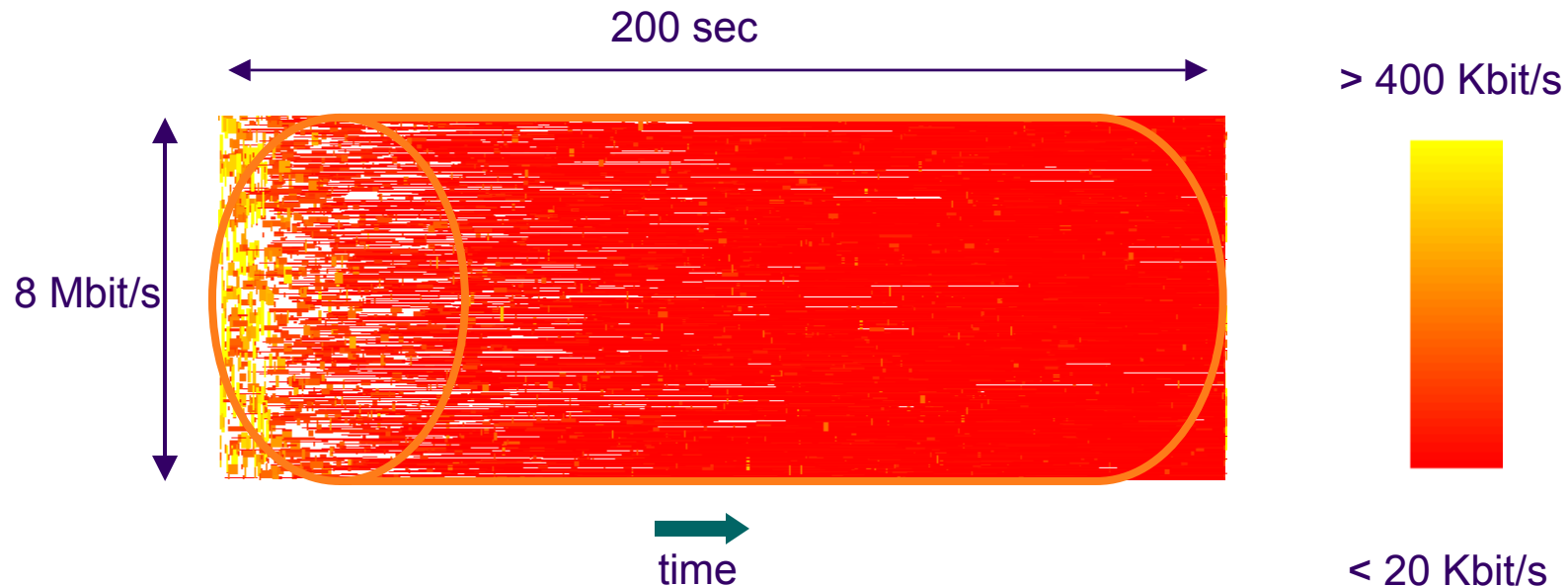
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  - ▶ failures
  - ▶ forecasting errors
  - ▶ traffic surges
  - ▶ deliberate choice (eg, some peering links)
- in overload the network is not transparent
  - ▶ arrival rate of new flows/sessions exceeds maximum service rate
  - ▶ throughput tends to zero ... until some flows are abandoned





# Simulation results: capacity 8 Mbit/s, load 140%

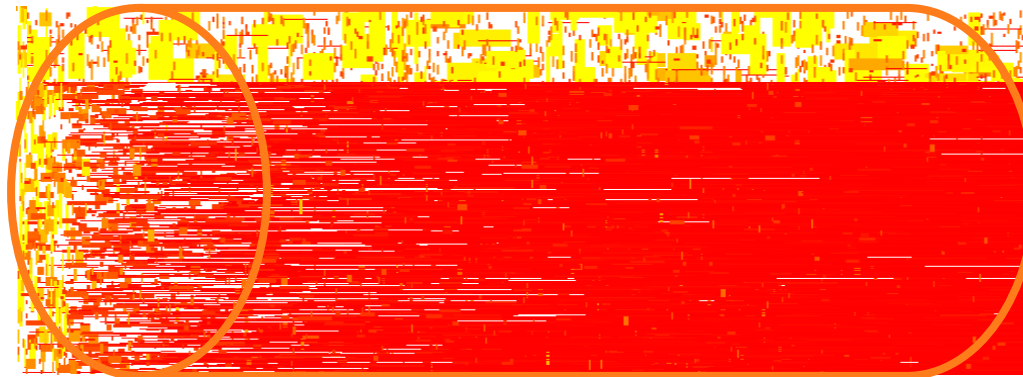
- per flow throughput tends to zero...
  - ▶ ... as new flows arrive faster than flows in progress complete



# Service differentiation



- reserve sufficient capacity for premium traffic
  - ▶ service models: Intserv, Diffserv, MPLS
  - ▶ mechanisms: priority queues, WFQ,...



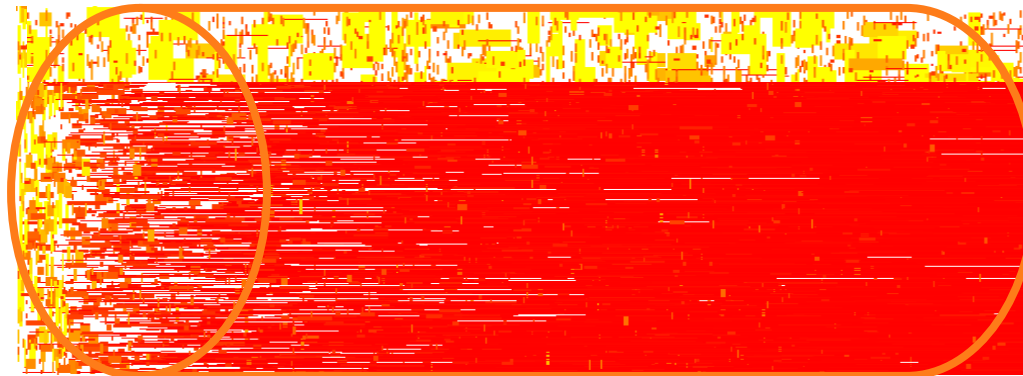
premium

best effort

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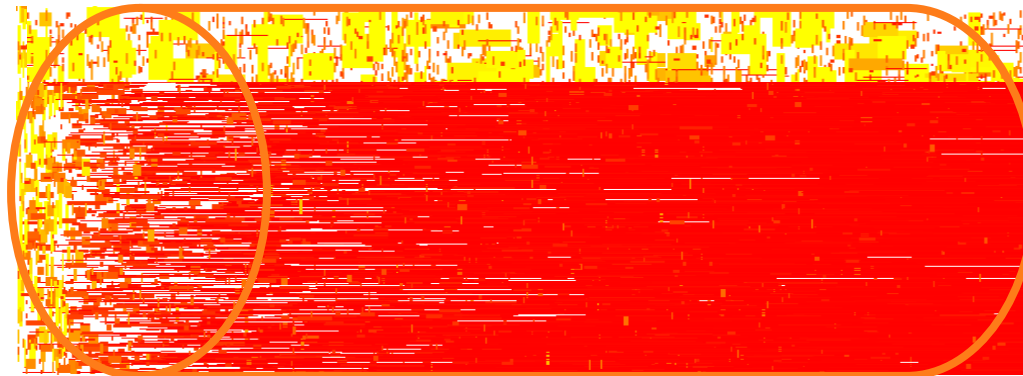
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- an alternative: preserve *transparency* by controlling *accessibility*
  - ▶ a flow-aware IP network architecture



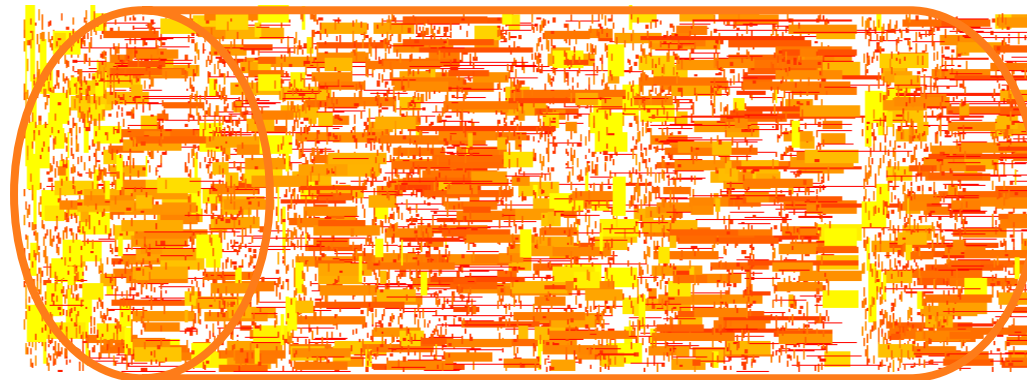
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# Flow-aware admission control



- only accept new flows if their transparency is assured
  - ▶ reject new flows when their throughput would be too small
  - ▶ for both streaming and elastic flows



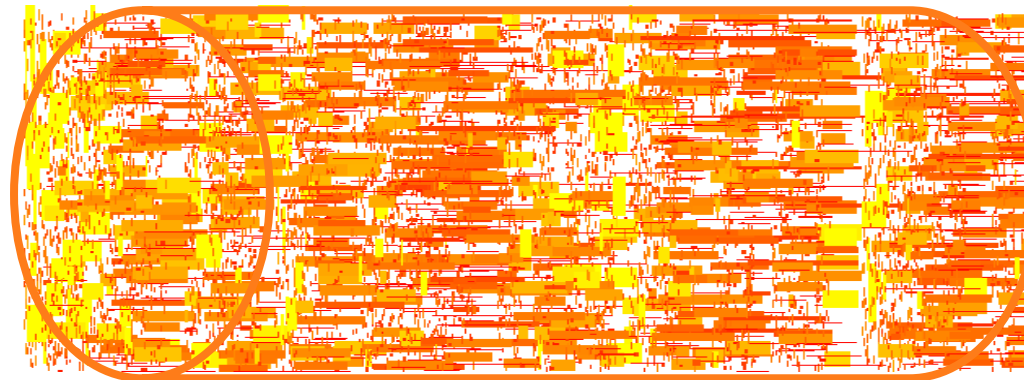
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admission control

# Flow-aware admission control



- only accept new flows if their transparency is assured
  - ▶ reject new flows when their throughput would be too small
  - ▶ for both streaming and elastic flows
- use different admission thresholds to provide differentiated accessibility
  - ▶ negligible blocking for premium traffic
  - ▶ all admitted flows are transparent and subject to charging



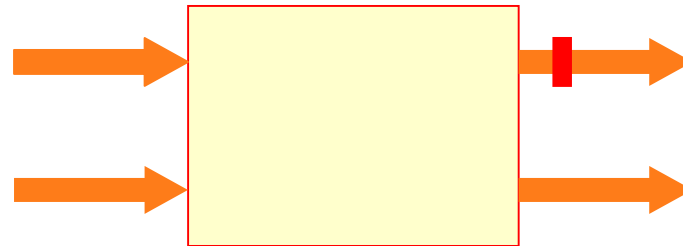
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admission control



# Implementing a flow-aware admission control

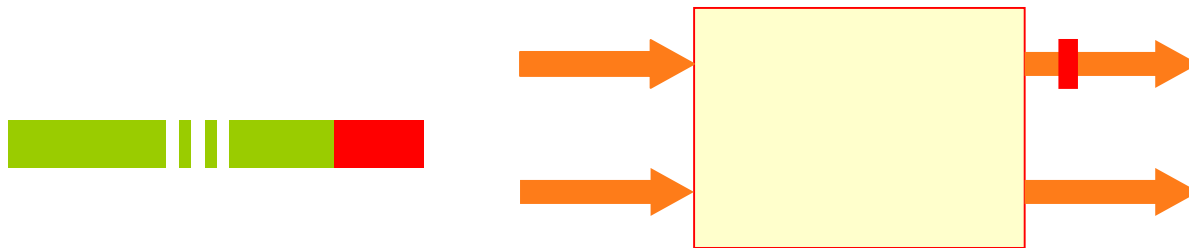
- no reservation, no signalling
  - ▶ an "enhanced best effort" architecture
  - ▶ localized admission control





# Implementing a flow-aware admission control

- no reservation, no signalling
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- flow identification
  - ▶ user defined, using a flow label + IP addresses
  - ▶ a table of flows in progress

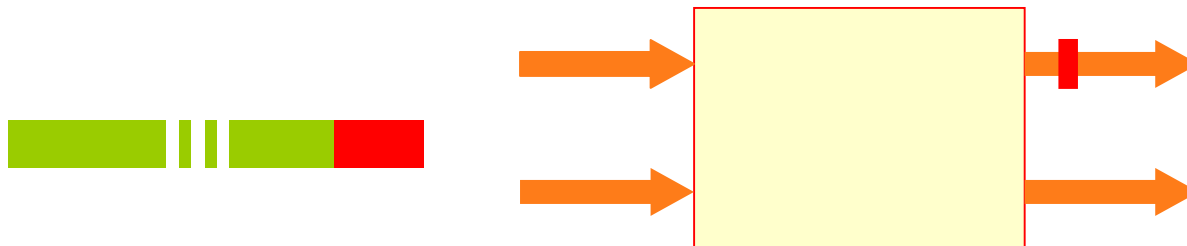


flow <sub>n</sub>	time <sub>n</sub>
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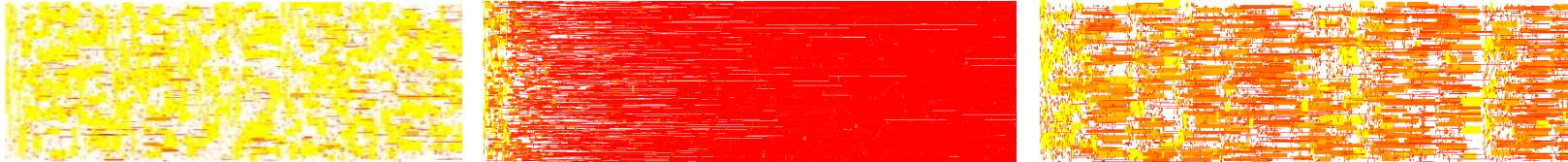
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- flow identification
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  - ▶ a table of flows in progress
- implicit admission control
  - ▶ measure current level of congestion
  - ▶ reject new flows when necessary by packet discard



flow <sub>n</sub>	time <sub>n</sub>
flow <sub>m</sub>	time <sub>m</sub>

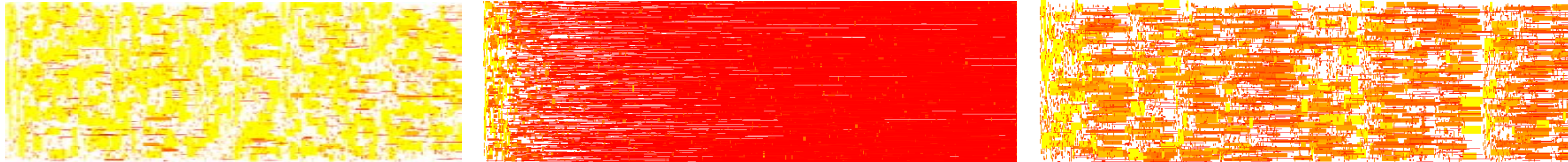
# Conclusions



- in normal load (i.e., demand/capacity  $< 1 - \delta$ ) the network is "transparent",
  - ▶ there is very little scope or need for service differentiation
- when demand  $>$  capacity, the network ceases to be transparent
  - ▶ (a phase change occurs)
- service differentiation can protect premium traffic...
  - ▶ but is wasteful and unnecessarily severe for best effort traffic
- flow by flow admission control constitutes an effective overload control
  - ▶ reject just the excess traffic, apply selective blocking
- realizing admission control: challenging but feasible
  - ▶ an implicit control: no signalling, no reservation!



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