Sustainable development and Internet: same battle?

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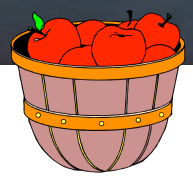
Introduction

- It's a talk about the similarities between our « globalized » world and the Internet
- In a couple of slides, I will try to explain these similarities…
- … and then try to give directions for the Internet world, using lessons learned from the problems that our « globalized » world is currently facing.
- Recent focus on sustainable development, green-effect and human responsabilities was at the beginning of this talk

Basics of economics in the human society

- Supply and demand is one of the most fundamental concepts of economics and it is the backbone of a market economy.
- The quantity demanded is the amount of a product people are willing to buy at a certain price
- There will be a complex relationship between producer (supply) and consumer (demand) in order to reach an equilibrium (nobody says that it will be a fair equilibrium!)

Producer-Consumer



- Basis of all commercial relationship.
- Relationship based on giving services/goods at a given price
- These (complex) relationships have ruled our society for centuries
- Globalization is the result of a « mature » commercial world
- Nowadays, globalization is emphasized by the integration of financial markets made possible by modern electronic communication.

The Internet « society »

- Complex digital world ruled by protocols and host computer acting as producer or consumer: web server/client, P2P…
- Born in the 70's, but has evolved at a much faster rate than the real world!
- The real & Internet world have both reach the « globalization » status, thus facing the same kind of problems!

Internet timeline

The 20th century of the Internet!

Ubiquitous, smart Internet?

Over-provisioning

DWDM

Internet 2, NGN

2000

Internet as you know it

1995

1990

ANSNET from MERIT, MCI, IBM

1983

ARPANET has 200 transit nodes

1974

TCP/IP for internetworking

1969

ARPANET was born with 4 transit nodes

1968

First transit node by BBN on DDP 316

1960

DoD project for a reliable, flexible network

Year 0

Looking for similarities?

More products/contents	
More hi-tech goodies	More digital contents
More strawberries in winter	More interactive applications
Low costs and prices	
Cheap hi-tech goodies!	Internet access deregulation
« Globalization » of labour	Unbundled accesses
More quality of service	
Next-day delivery service	Delay-sensitive applications
No shortage of goods	Bandwidth consuming P2P
	IPTV and VoD

Looking for similarities?

More products/contents	
More hi-tech goodies	More digital contents
More st	ications
Chea	gulation
« Globo	ses
Next-g	cations
No shortage of goods	Bandwidth consuming P2P
	IPTV and VoD

Provide more satisfaction
To more and more people

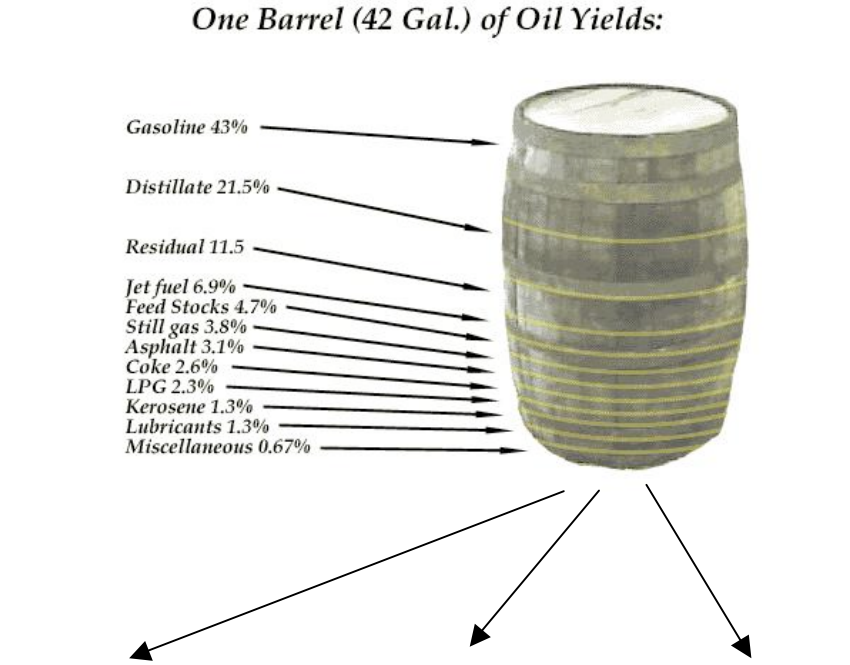
but

People does not want to wait

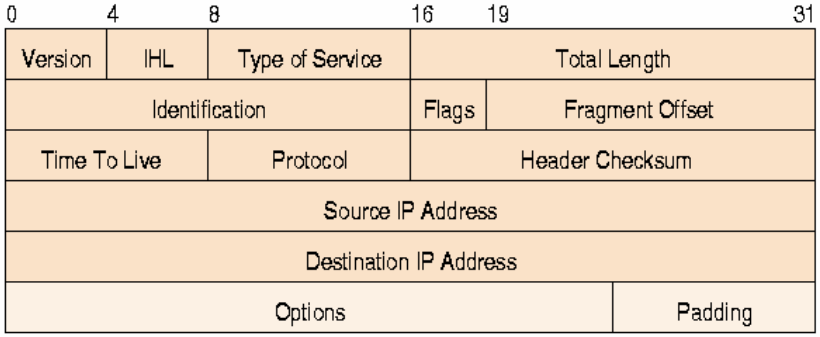
so

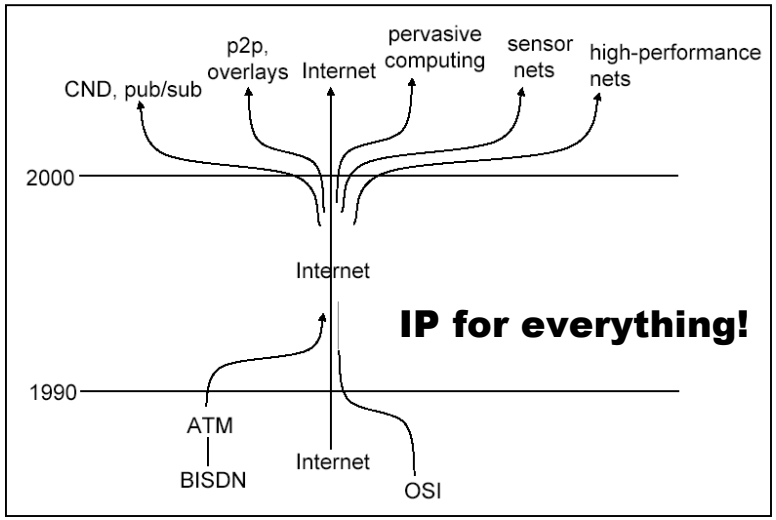
Use existing technologies and pray that they scale!

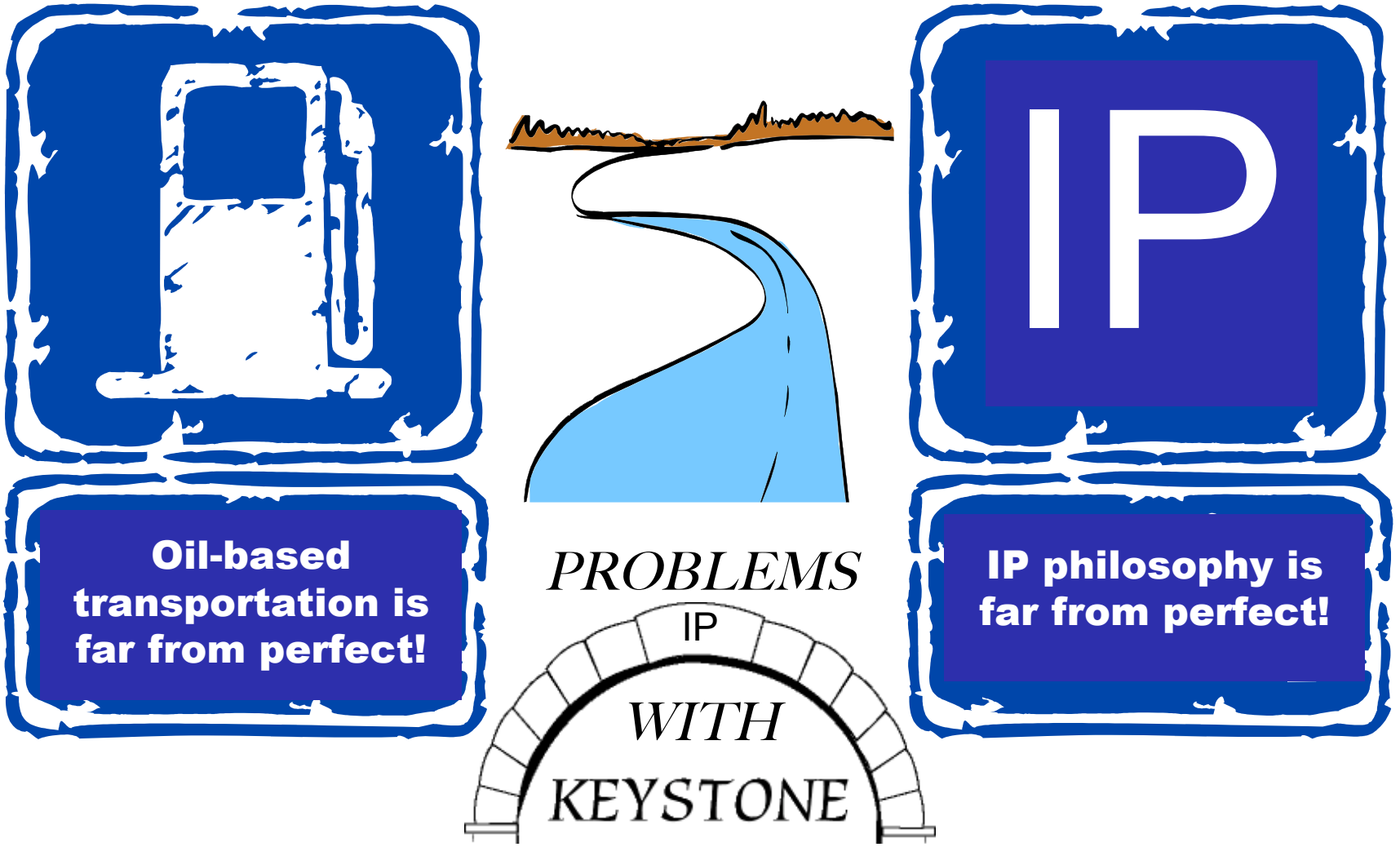
Keystones of our (e)society



Heating fuel	Petro-chemicals	Gazoline
-houses	-Candles	-Car
-Industries	-Paints	-Planes
-Electricity	-Soap	-Train
-…	-Perfume	-Ship
	-Insecticide	-…
	-Polyester	
	-…	







If you remove it…everything crashes

finding alternatives is difficult,
incremental deployment takes time

If you were an IP packet…

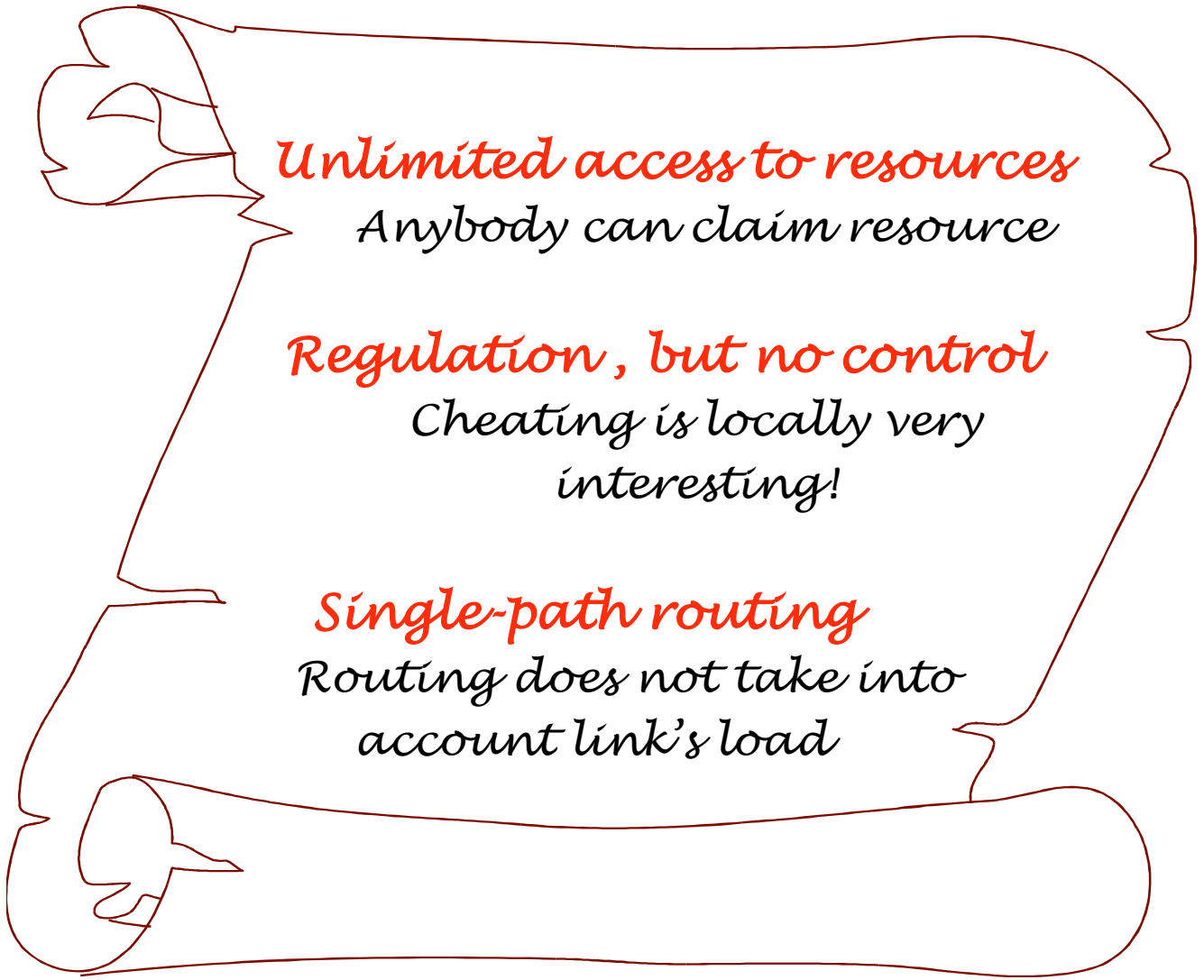
(or the IP version of the game of the goose!)

- …travelling from Pau to New-York
  - you will have no choice on your routes nor transportation means
  - if you are travelling with your companion, you will not be guaranteed to travel together!
  - when stoping at a city without accomodations, you will have to retry from your departure point!
  - at any city, cops can hold you for an undetermined amount of time, or simply put you definitely in jail!
  - then, you have no upper bound for the time your journey will take!
- Good news: you have an unlimited number of retries!

IP desired service

- Isolation: my traffic is not impacted at all by yours
- Protection: my transmission path is backed up to the nth degree by failover paths
- Throughput: I get the capacity I pay for
- Delay: Whatever pattern of packets timing I send with is preserved at the far-end

The Internet "rules"



Unlimited access to resources

Anybody can claim resource

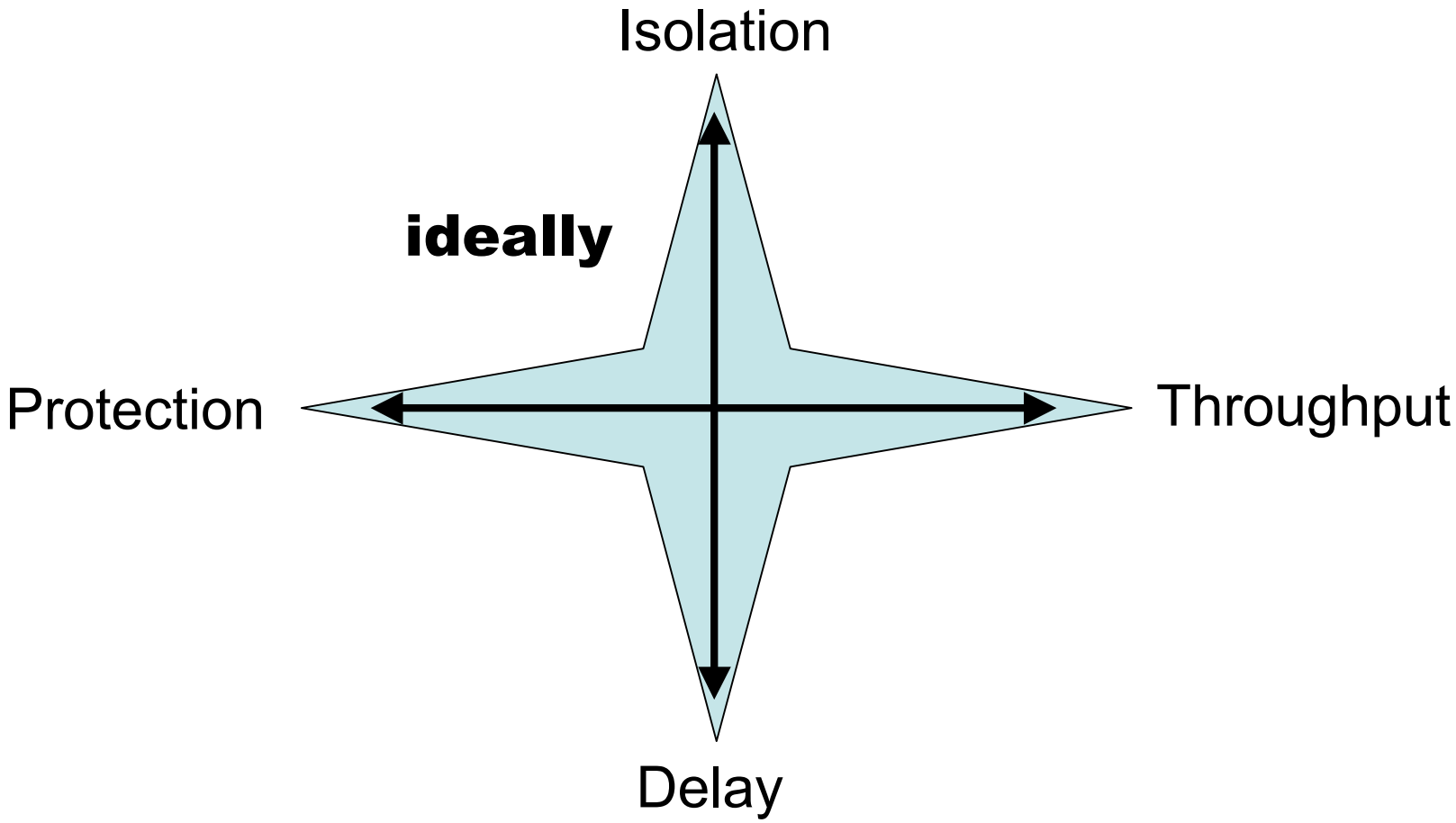
Regulation, but no control

Cheating is locally very interesting!

Single-path routing

Routing does not take into account link's load

The throughput quest



The throughput quest

P2P, WEB,…

Isolation

Protection

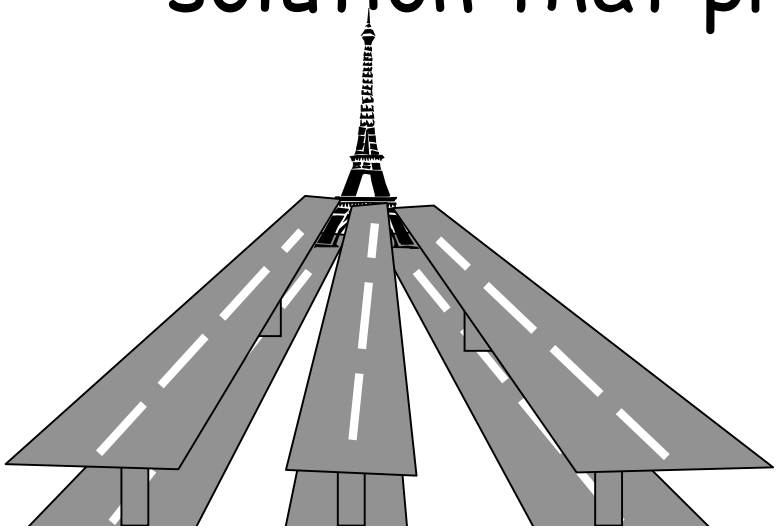
Throughput

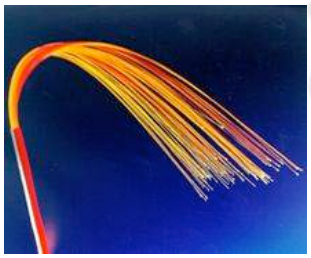
Delay

what we have

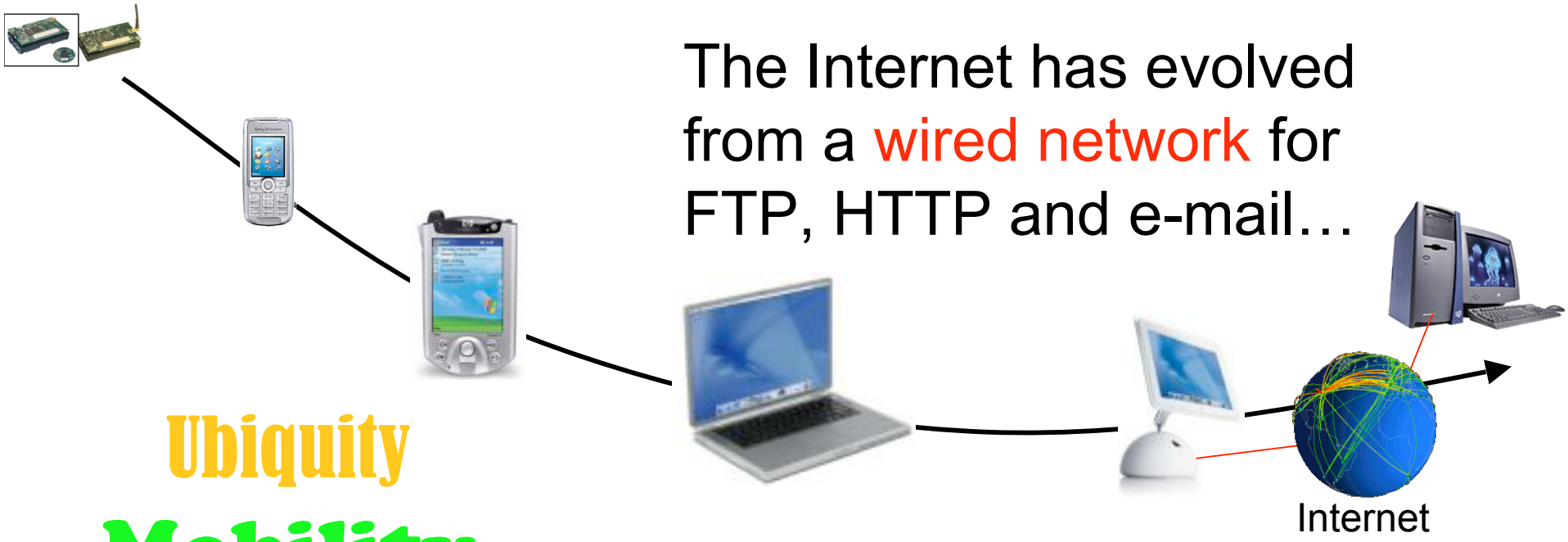
Overprovisioning in the core

- Most operators are overprovisioning bandwidth with DWDM fibers
- 10Gbps, 40Gbps, 160 GBps, 320 Gbps
- Overprovisioning is a short-term solution that prevents optimizations





What's wrong?



The Internet has evolved from a wired network for FTP, HTTP and e-mail…

Ubiquity

Mobility

Ad-Hoc

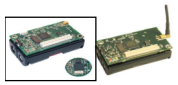
Telephony

MULTIMEDIA

Streaming

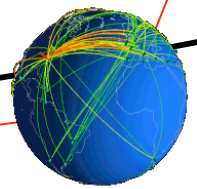
… to a fantastic infrastructure with a large variety of communicating devices and high diversity of access and traffic characteristics

What's wrong?



The Internet has evolved from a wired network for FTP, HTTP and e-mail…

" …the world has changed, the use of the Internet has changed and, fundamentally, the architecture has not evolved to take account of that. " (P. Howell, BT)



Internet

Ubiqu

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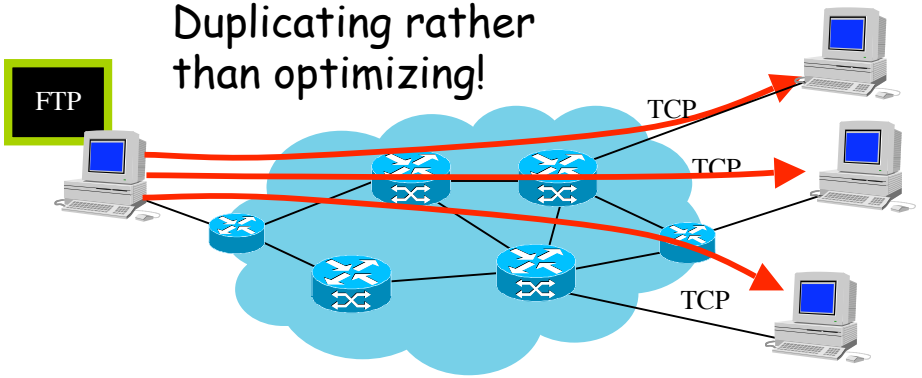
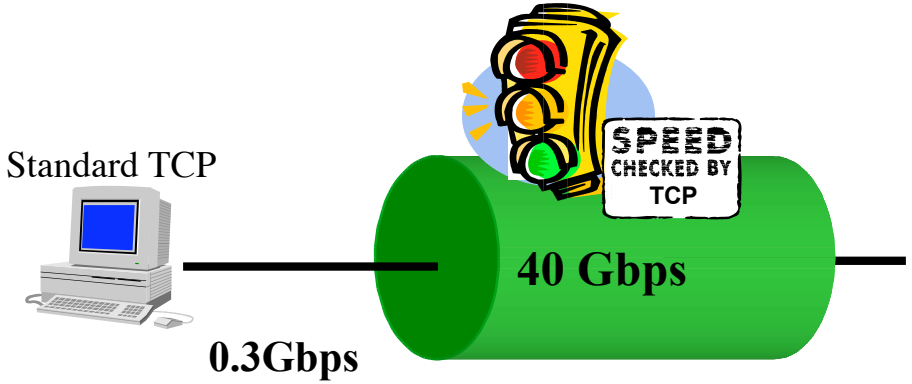
… to a fantastic infrastructure with a large variety of communicating devices and high diversity of access and traffic characteristics

Overprovisioning: a huge waste of resources





If you want to transfer a 1GB file with a standard TCP stack, you will need minutes even with a 40Gbps (how much in $?) link!

Sustainable development

- "meets the needs of the present without compromising the ability of future generations to meet their own needs" [Brundtland Report, 1987]
- Trade-off between performance and needs: « why are we producing? »
- Use the right ressource, at the right place, at the right time

a new dimension of global responsibility—
not only to planetary resources but also to planetary fairness

Is overprovisioning harmful?

- NO: overprovisioning is not very costly. Adding new wavelengths is quick. Customers are happy and quick return on investment!

- YES: while overprovisioning, alternative solutions are not deployed. High risk that relying too much on old technologies makes upgrades impossible (c.f. IPv6, TCP,…)

Is overprovisioning harmful?

- NO: overprovisioning is not very costly.
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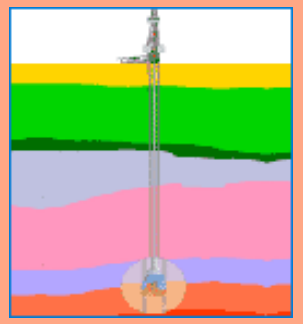


Each new oilfield discovery delays research and development of alternative energies

What we know vs what we do

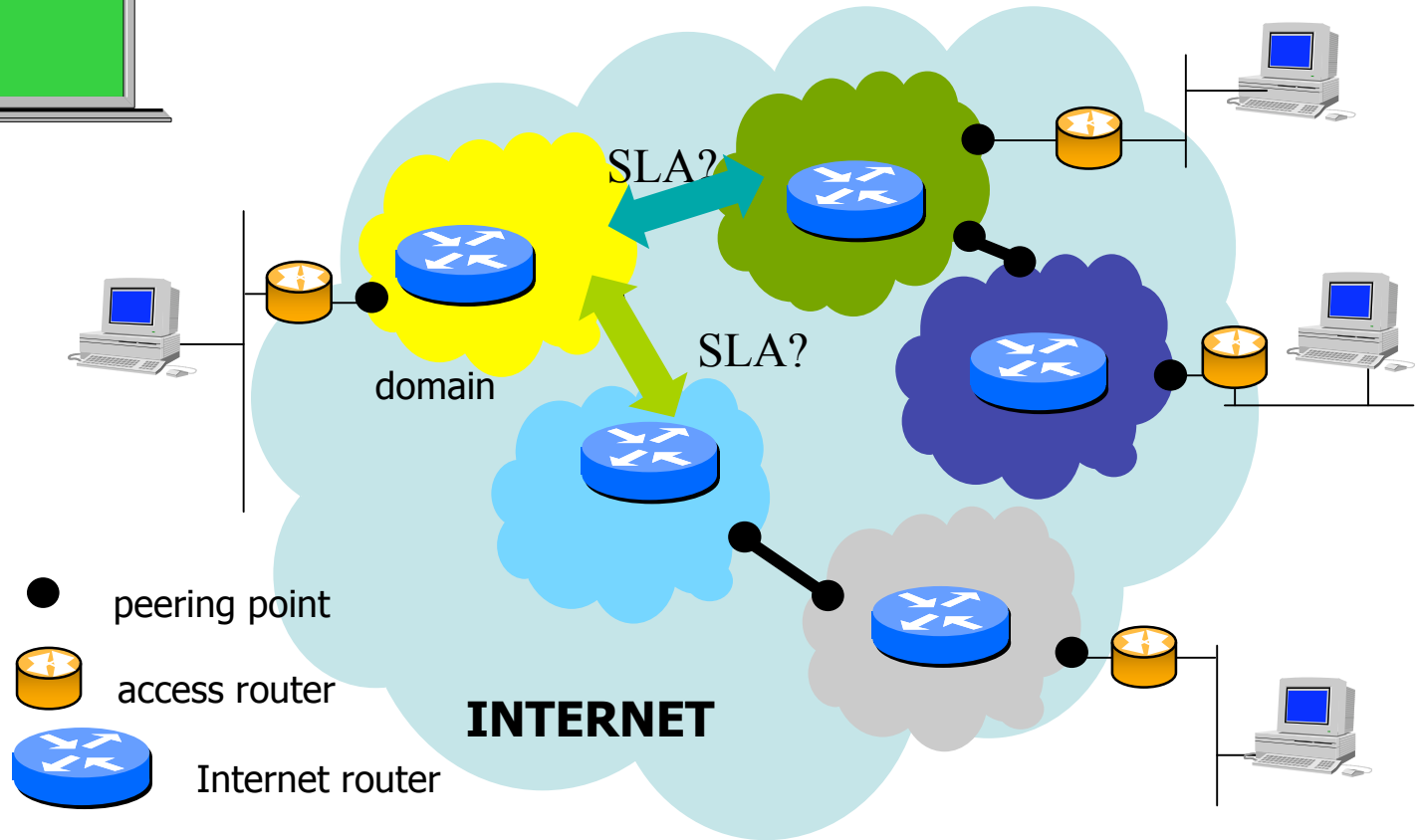
- Quality of service, SLAs are useful
- Admission control is necessary
- Inter-Domain QoS Provisioning and Accounting
- Scheduling and AQM are beneficial
- Congestion control is mandatory

- Best-effort is the de-facto standard
- No-control, no-limit, no sanction
- No interoperability, limited deployment, no global policy
- FIFO and Drop-tail are mostly deployed
- None in multicast, UDP, RTP

It's not my fault!

« environmental problems often have impacts beyond borders »

- What's the point of deploying QoS if others don't?



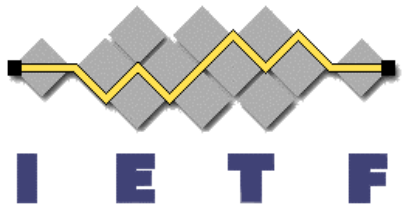
Towards sustainable development

- Organizations
- Laws and rules
- Financial counterpart
- Control for irregular behavior
- (Sanctions)

GREENAWARDS
FOR CREATIVITY IN SUSTAINABILITY

What control do we have on the Internet?

- Organizations: IETF, ISOC, IAB
- Laws and rules: TCP/IP, RFCs
- Financial counterpart: ∅
- Control for irregular behavior: ~∅
- Sanctions: ∅



Lessons learned from sustainable development

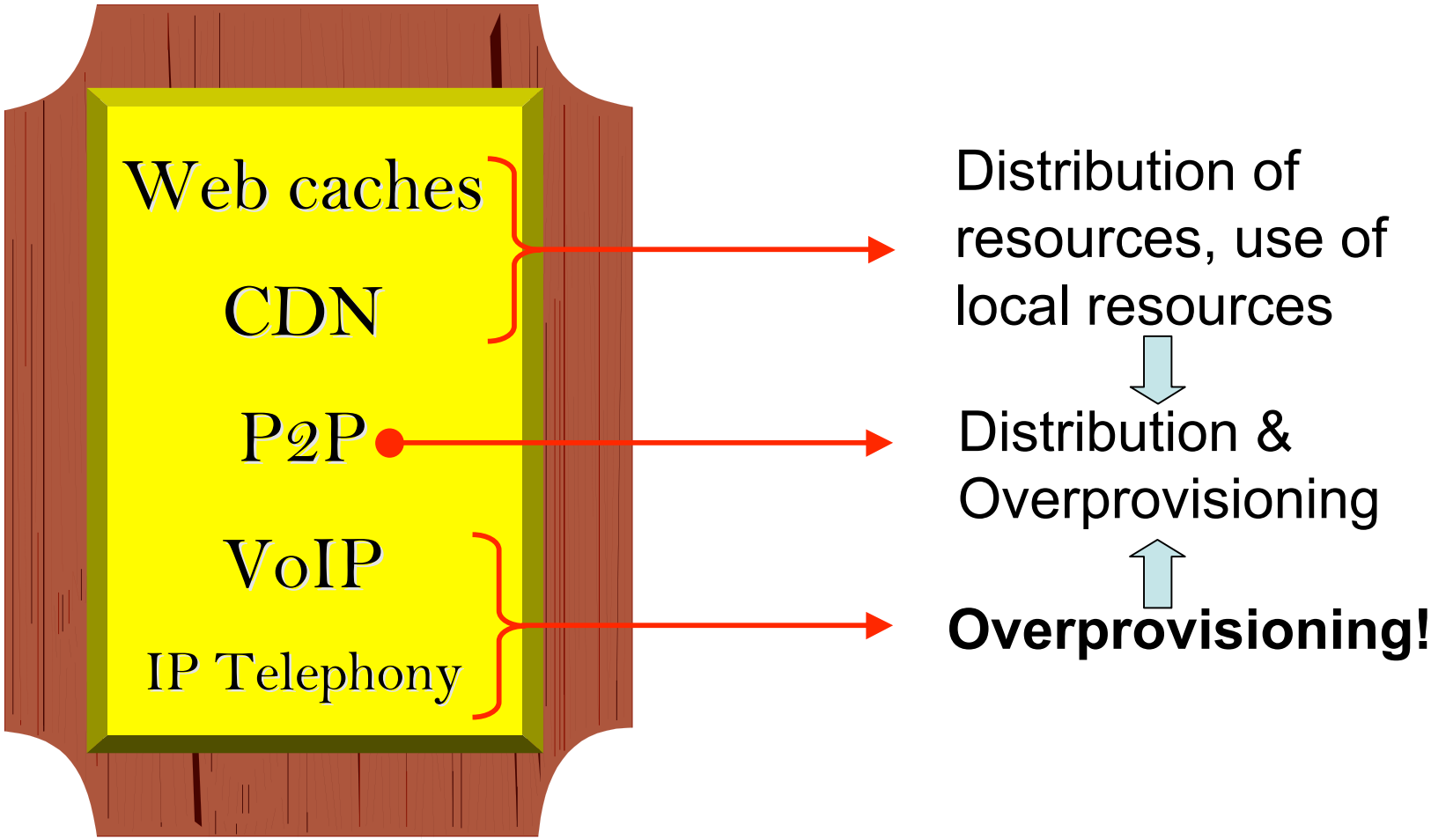
- Limit globalization
- Limit the pursuit of continued economic prosperity
- Redistribute labour, wages,…
- Promote the use of local resources
- Change mentality

Net Neutrality or Not?

- NN or NNN? That's the question!
- NN = dumb network!
- Internet's success is in a large part debtful to what's called Net Neutrality (IP neutrality)
- So is the evolution of our society!

Can we afford to continue blind, unconcious development?

Some success stories



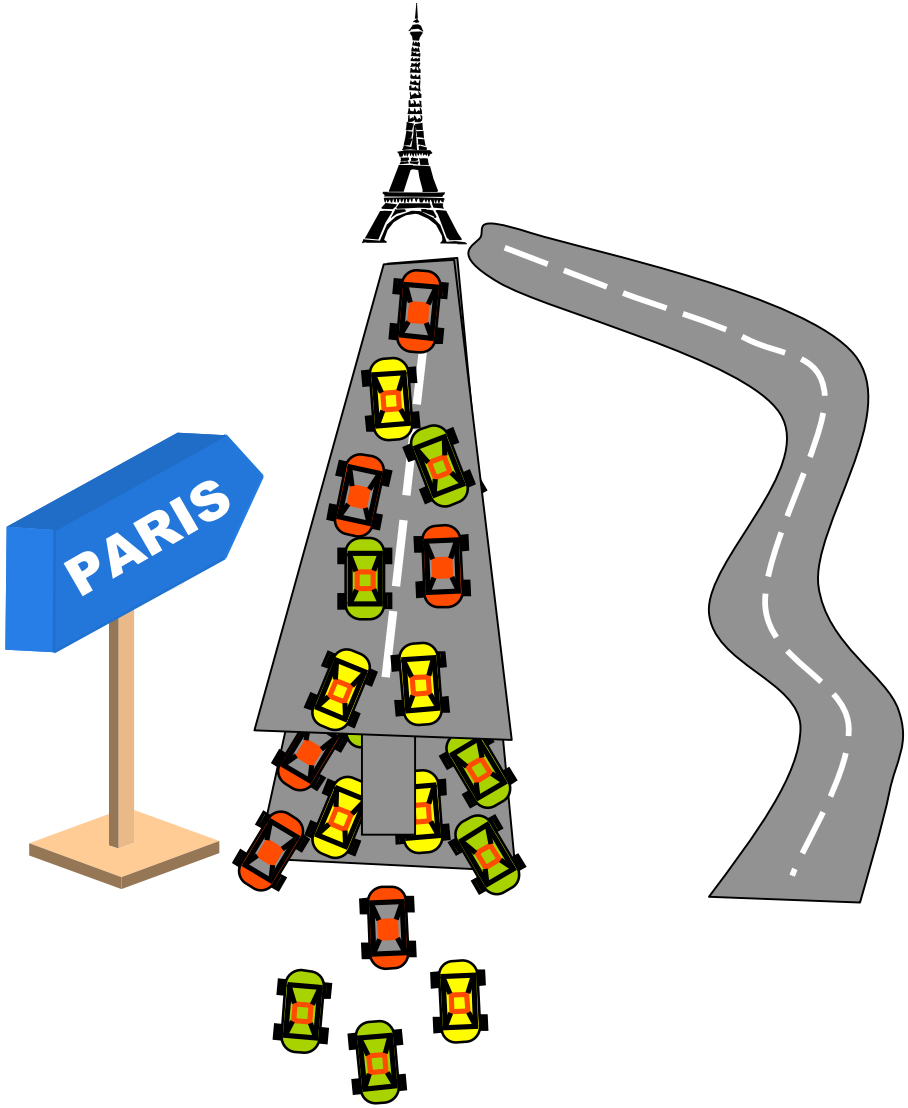
Domains of application

- Routing
- Security
- Multicast
- Congestion control

Routing

- Common idea of multi-path routing on the Internet is FALSE!
  - There are several physical paths, but only one is kept by the router!
  - Usually, link's cost depends on the capacity, not the available bandwidth!
- Routing in the Internet is highly static!

Why single-path is foolish!



Why single-path is foolish!

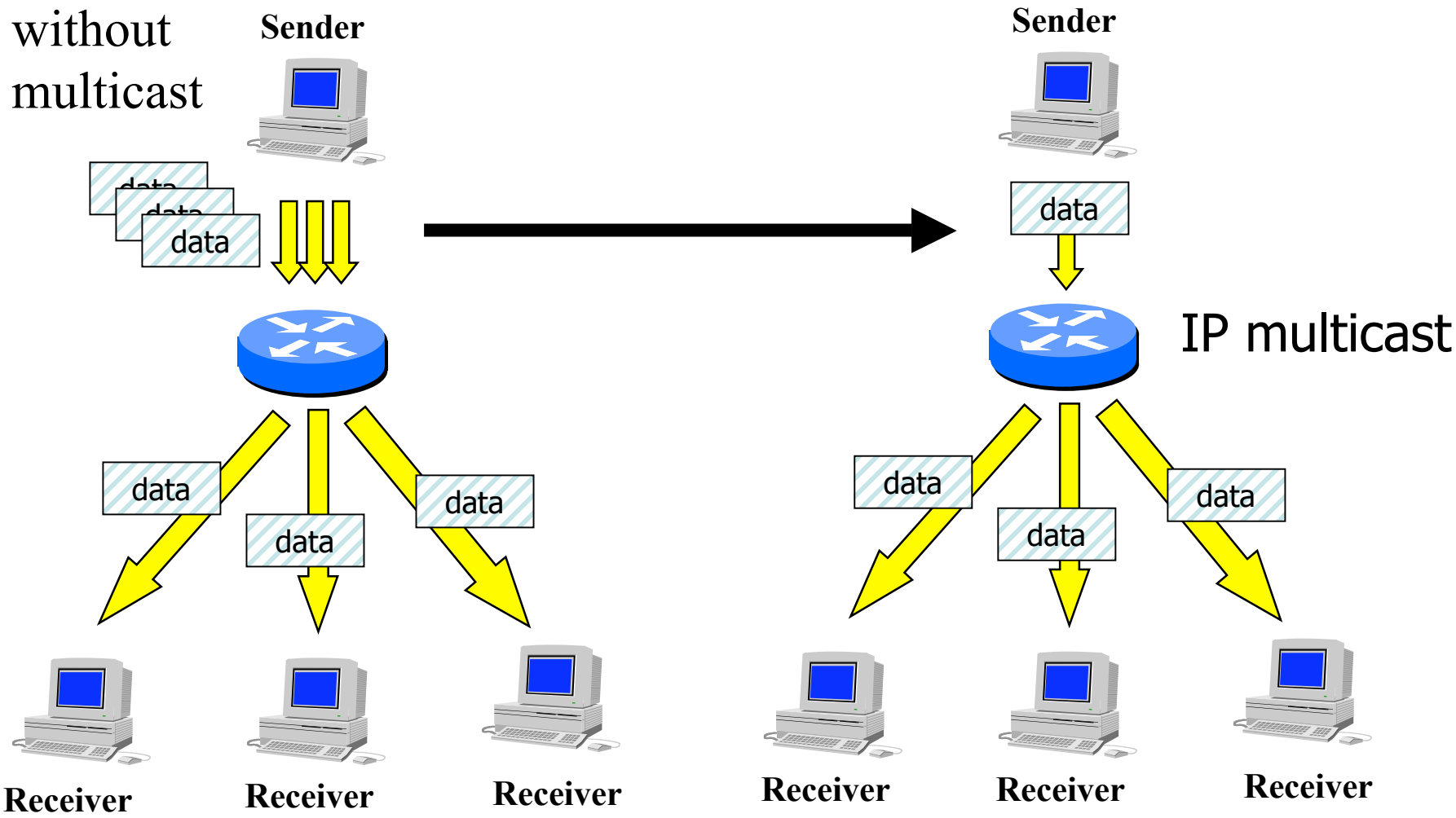
Overprovisioning temporarily "solves" the shortage of bandwidth on the critical path

What about more intelligence in the networks, use load information?

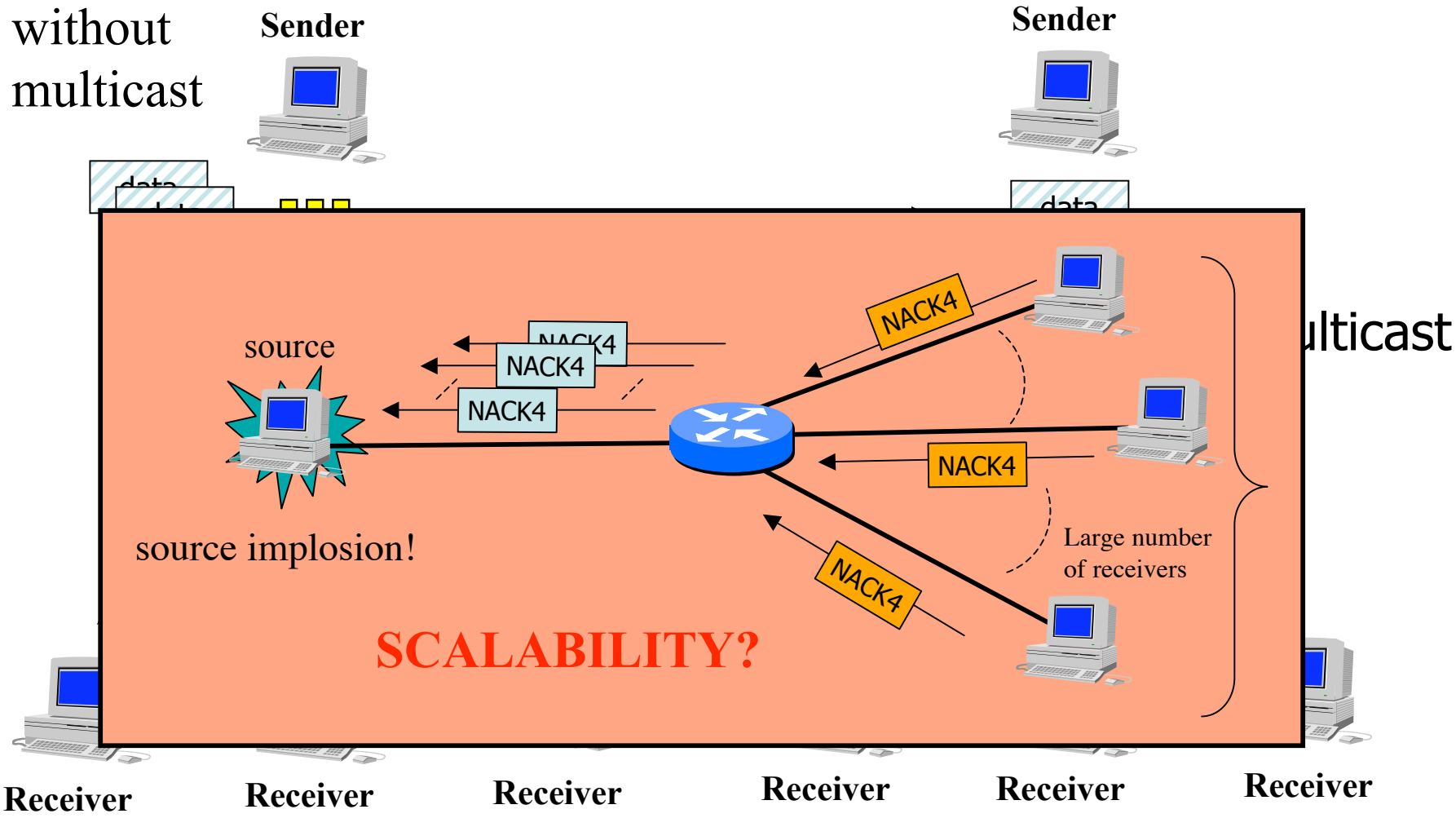
Security

- To be done :-(

Multicast

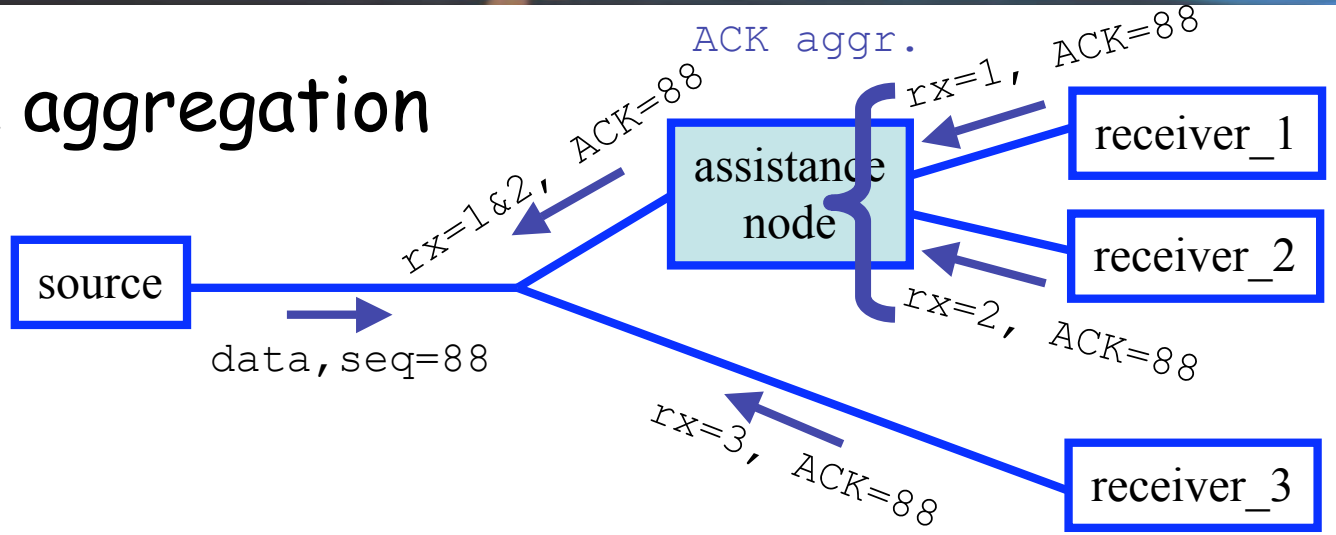

without multicast
Sender
data
data
data
data
data
Receiver
Receiver
Receiver
Sender
data
IP multicast
data
data
data
Receiver
Receiver
Receiver

Multicast

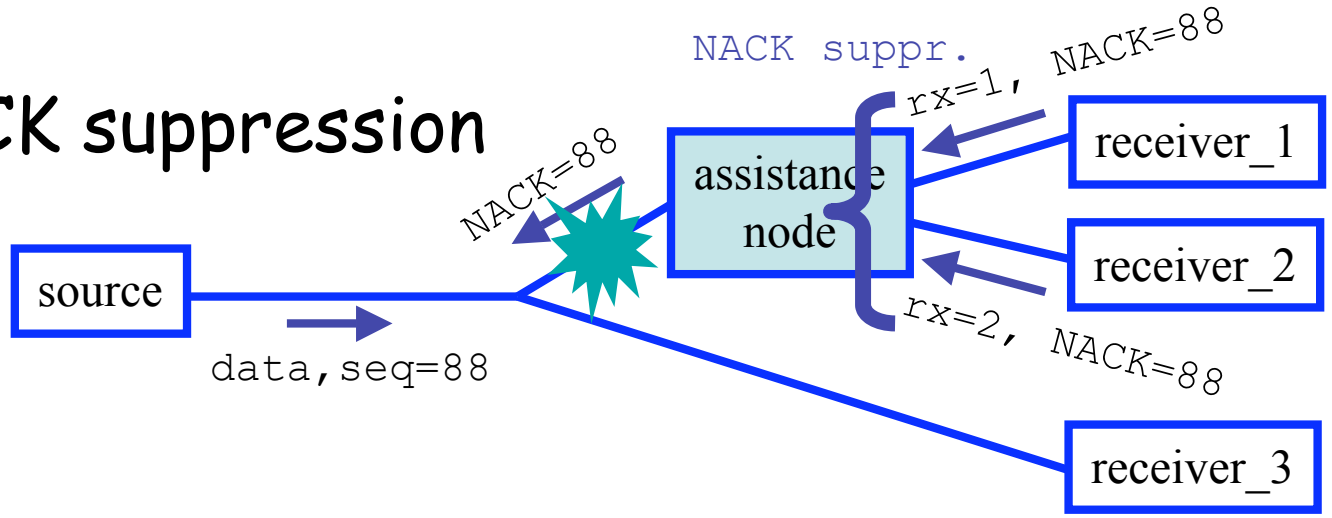

without multicast
Sender
Sender
source
NACK4
NACK4
NACK4
NACK4
NACK4
NACK4
source implosion!
Large number of receivers
SCALABILITY?
ulticast
Receiver
Receiver
Receiver
Receiver
Receiver
Receiver

Feedback aggregation

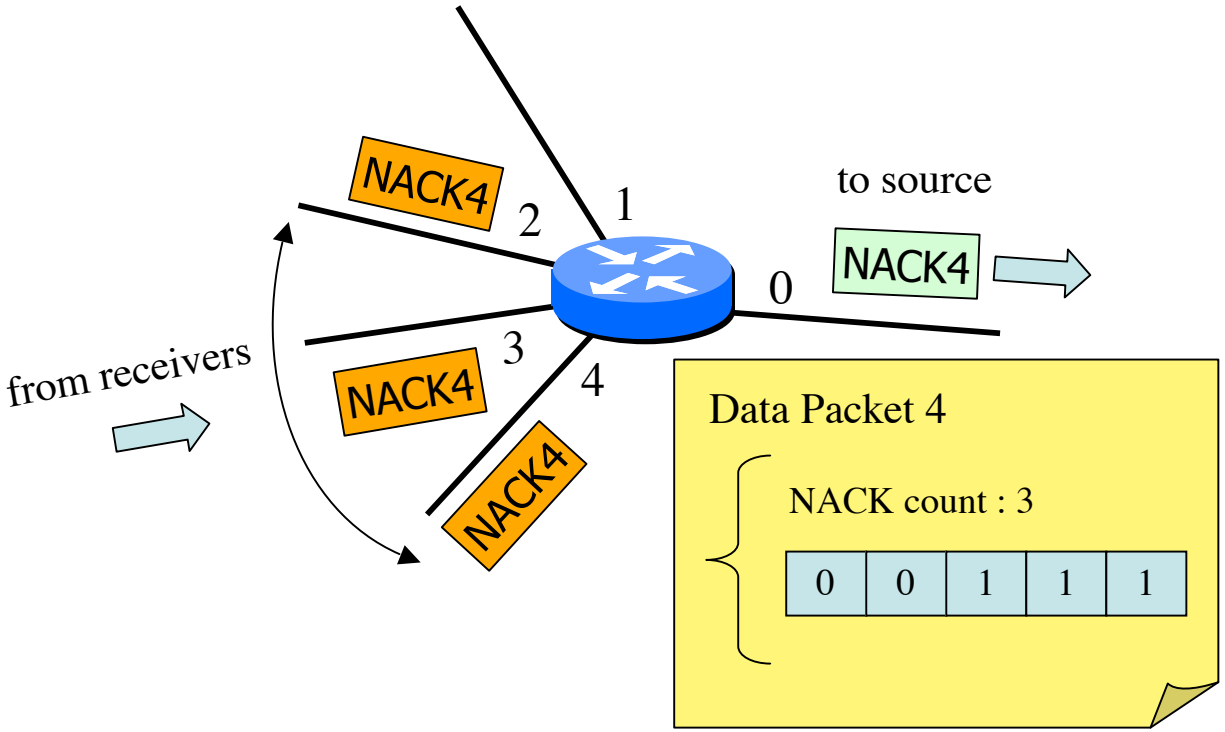
- ACK aggregation



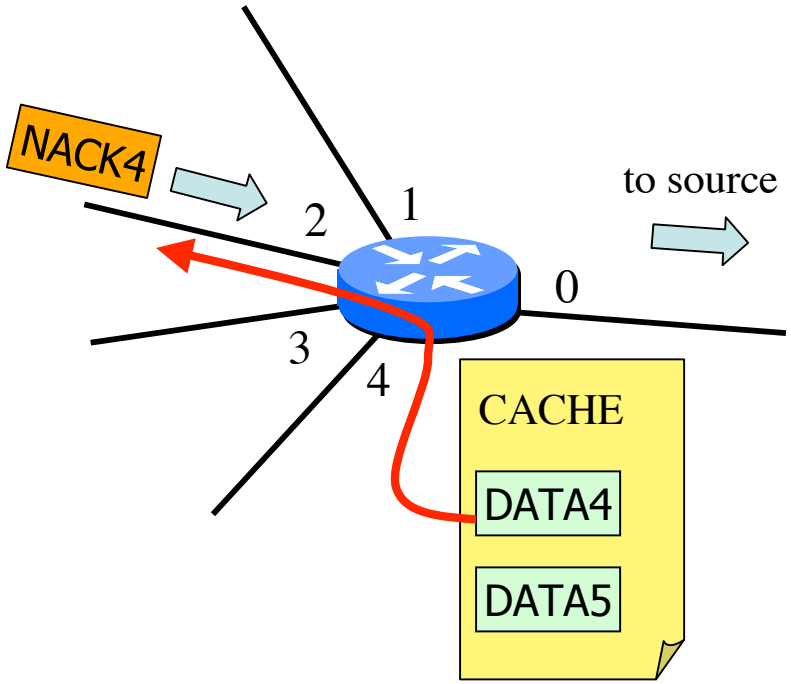
- NACK suppression



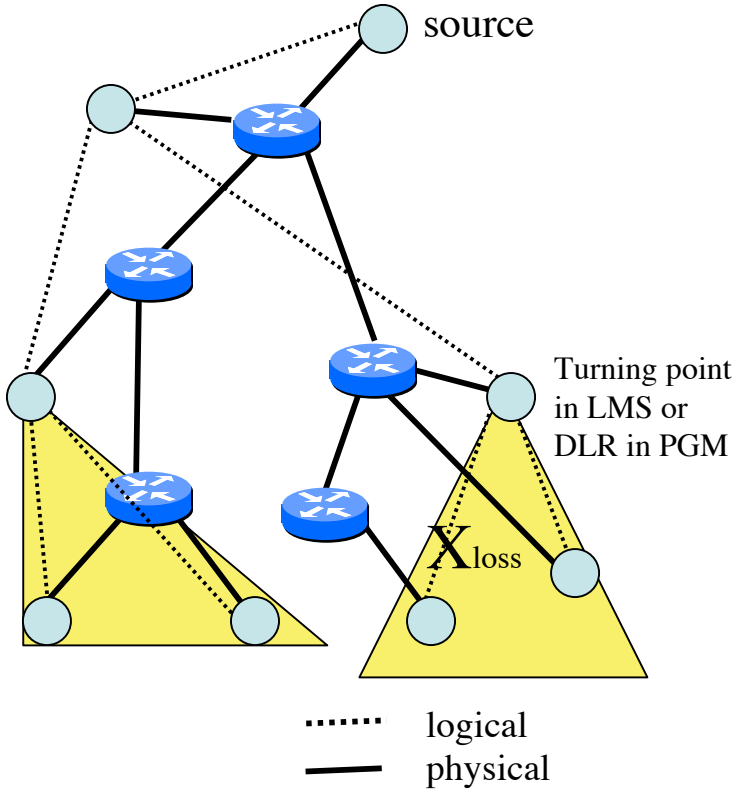
Implementing NACK aggregation



Advanced functionnalities

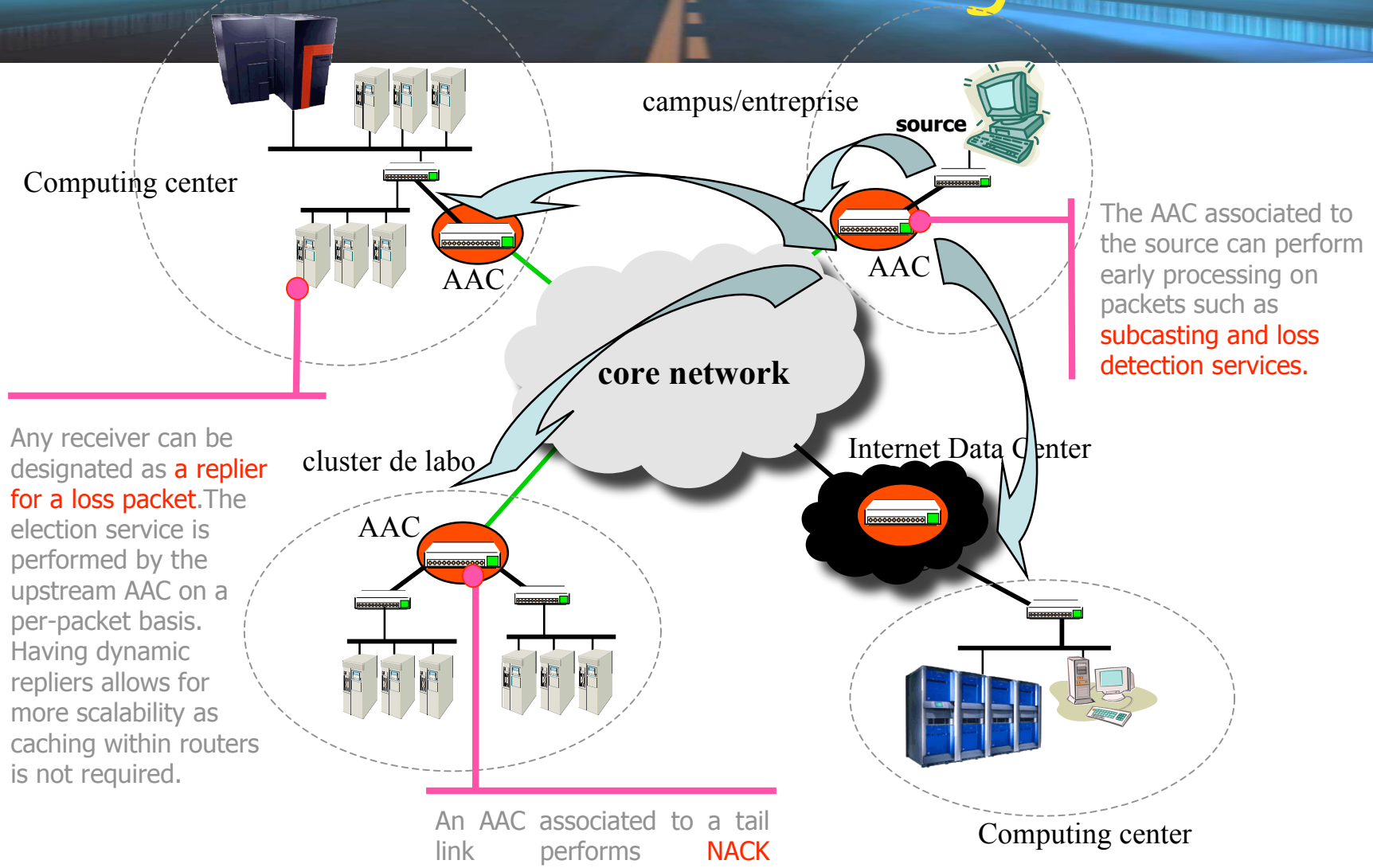


Data packet cache



Representative election

Illustration on a grid



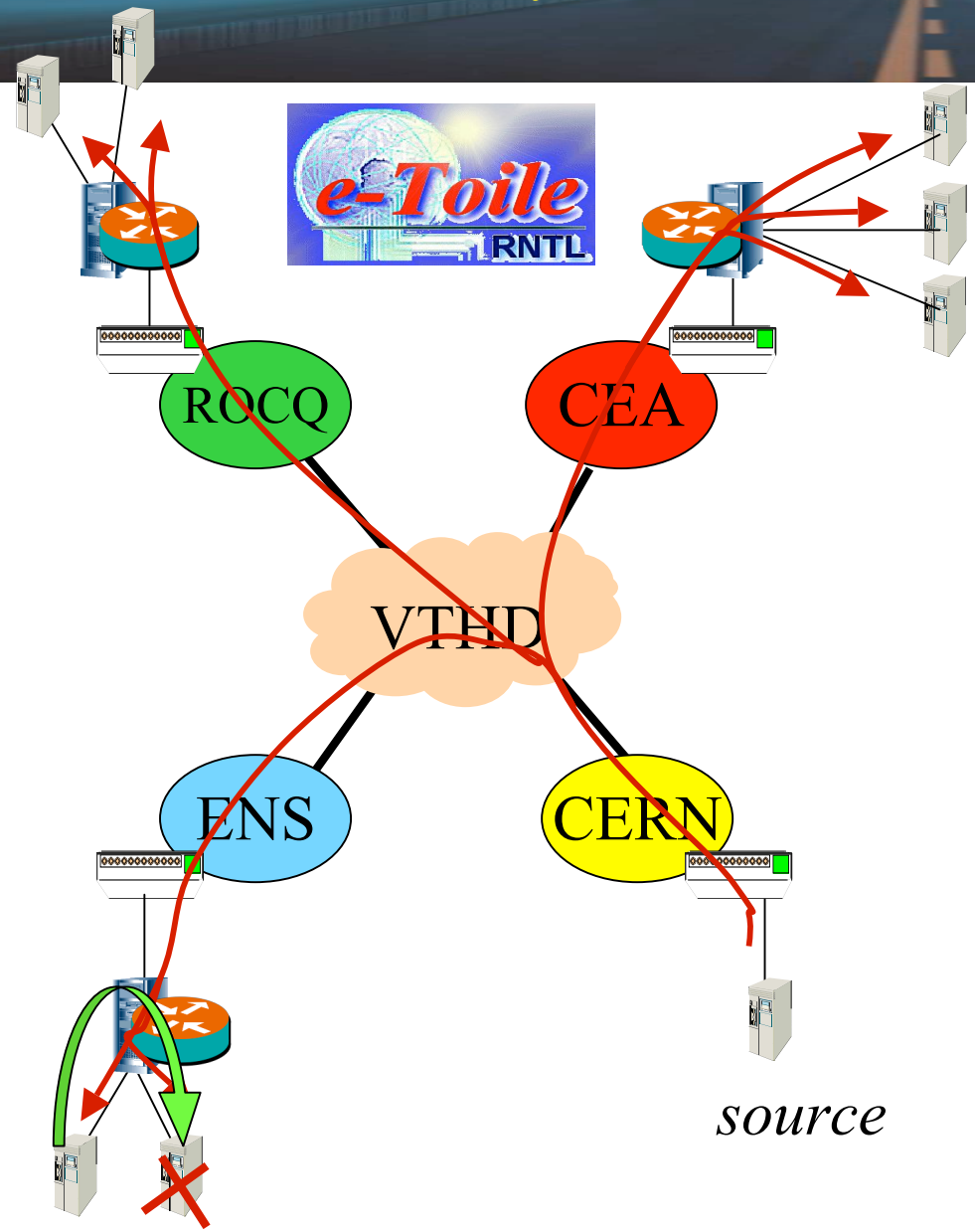
The AAC associated to the source can perform early processing on packets such as subcasting and loss detection services.

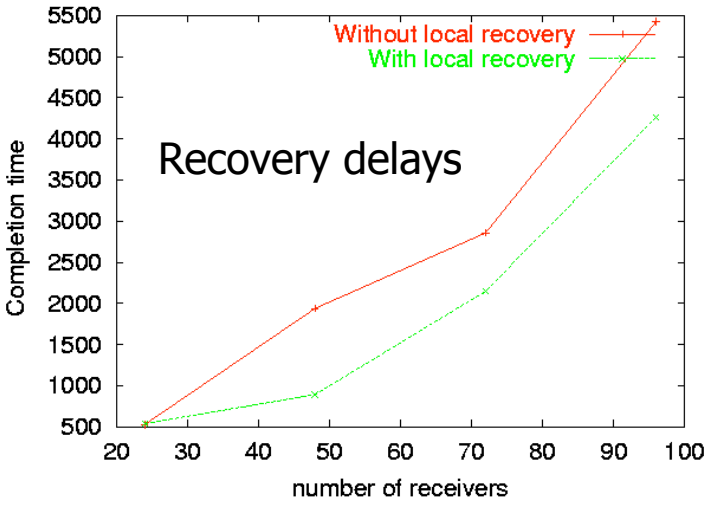
Any receiver can be designated as a replier for a loss packet.The election service is performed by the upstream AAC on a per-packet basis. Having dynamic repliers allows for more scalability as caching within routers is not required.

An AAC associated to a tail link performs NACK aggregation, subcasting and the election on a per-packet basis of the replier.

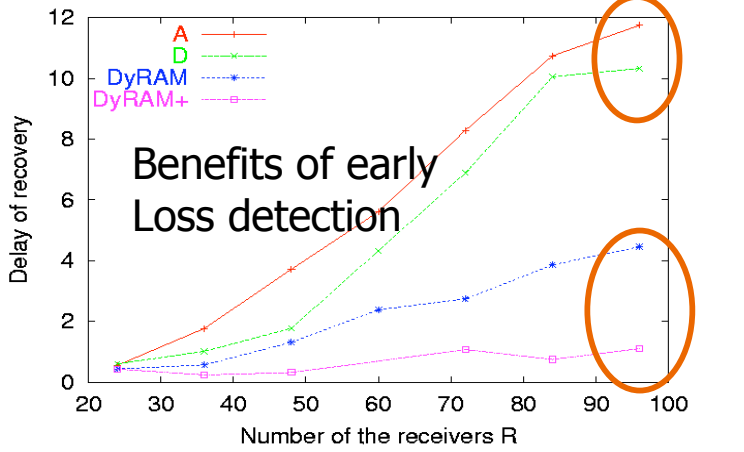
AAC: ***application-aware component***

Demo for the RNTL e-Toile

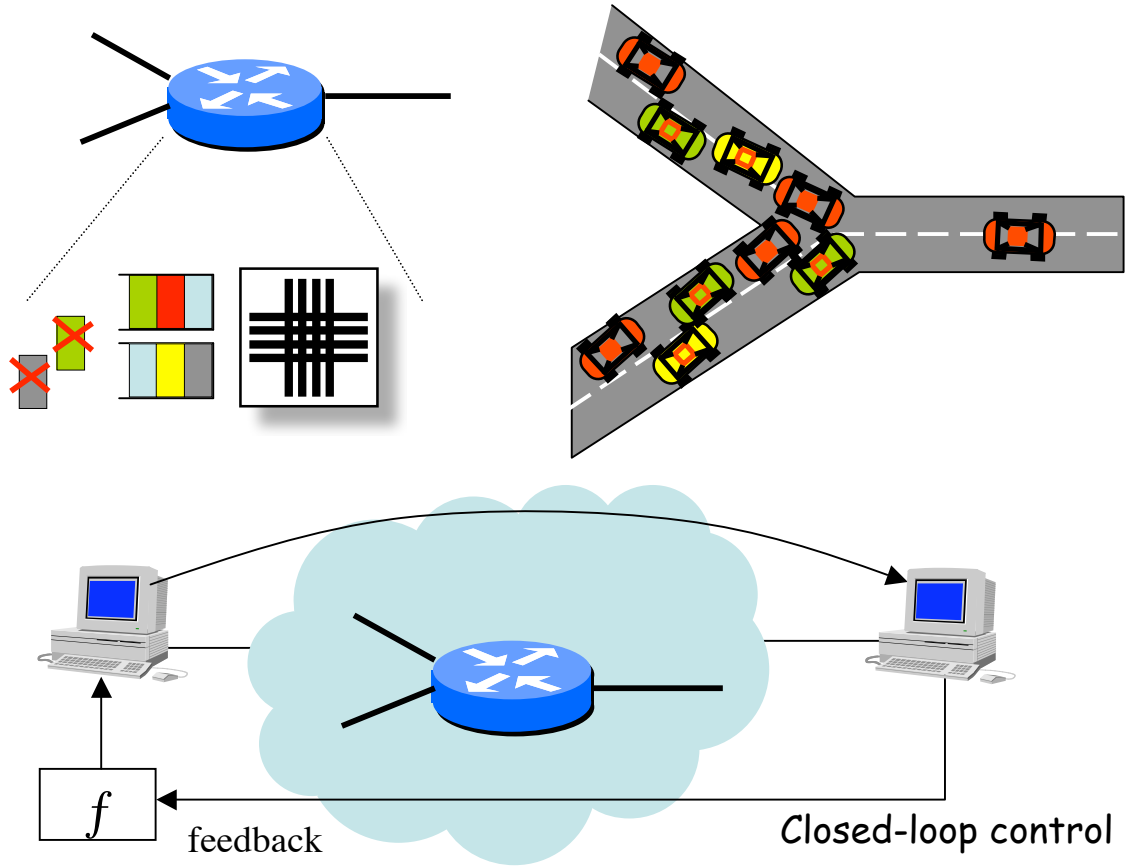




4 receivers/group #grp: 6...24

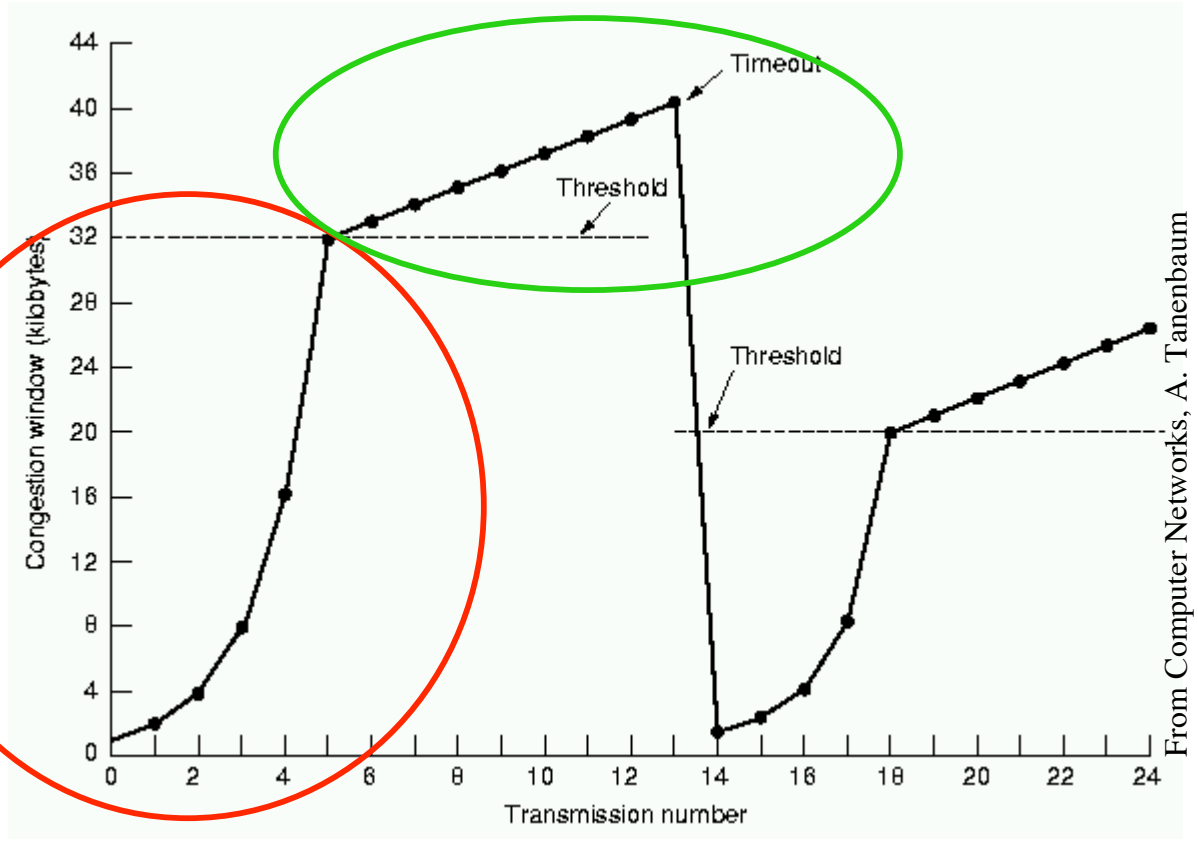


Congestion Control



Feedback should be frequent, but not too much otherwise there will be oscillations
Can not control the behavior with a time granularity less than the feedback period

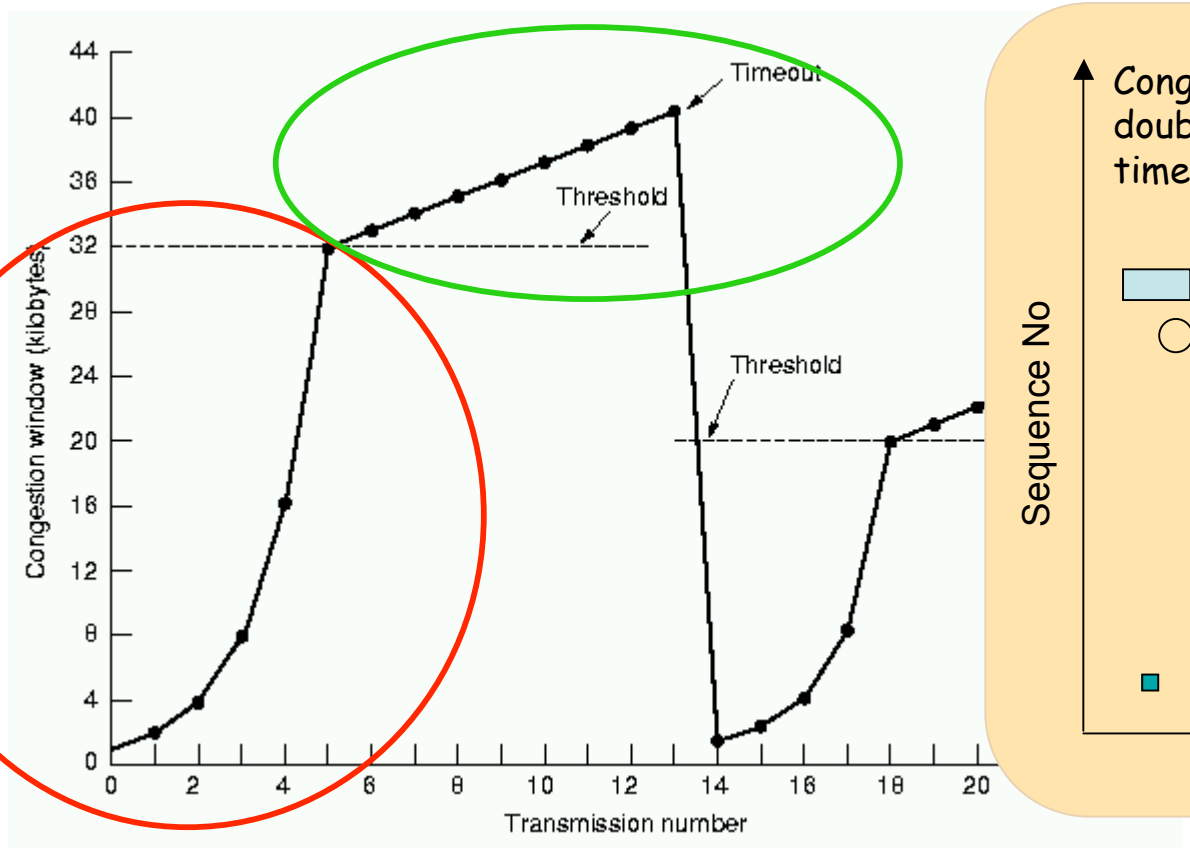
TCP congestion control

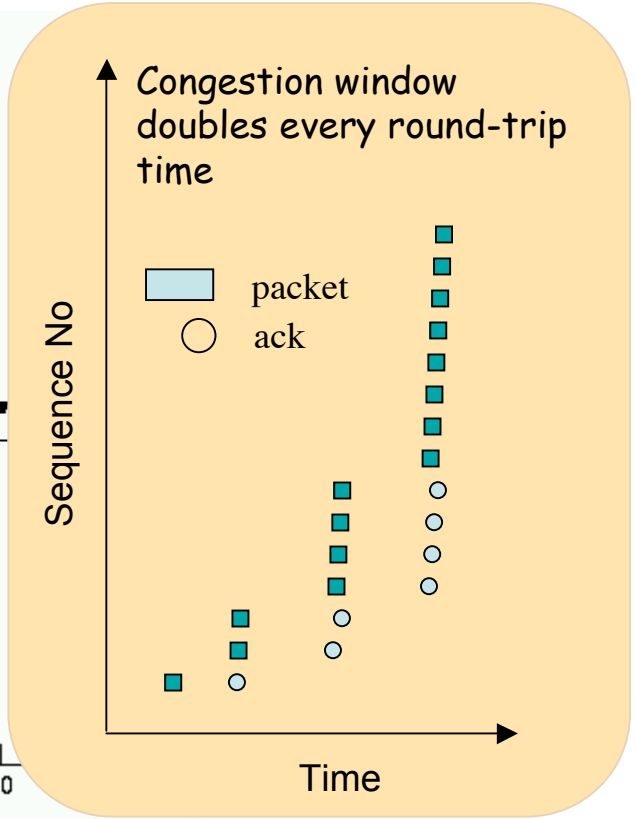


cwnd grows exponentially (slow start), then linearly (*congestion avoidance*) with 1 more segment per RTT

If loss, divides threshold by 2 (multiplicative decrease) and restart with cwnd=1 packet

TCP congestion control





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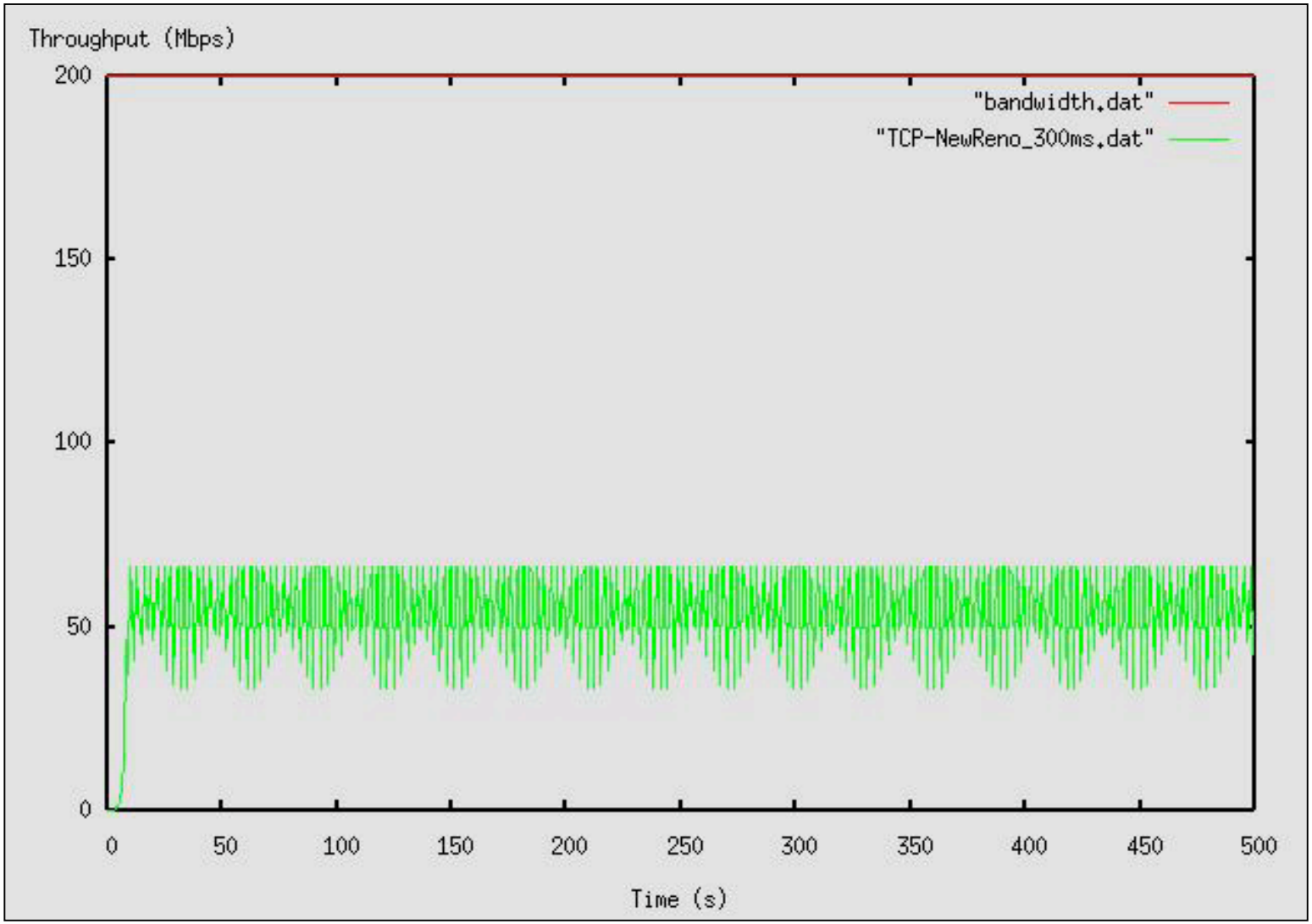
The reality check: TCP on a 200Mbps link



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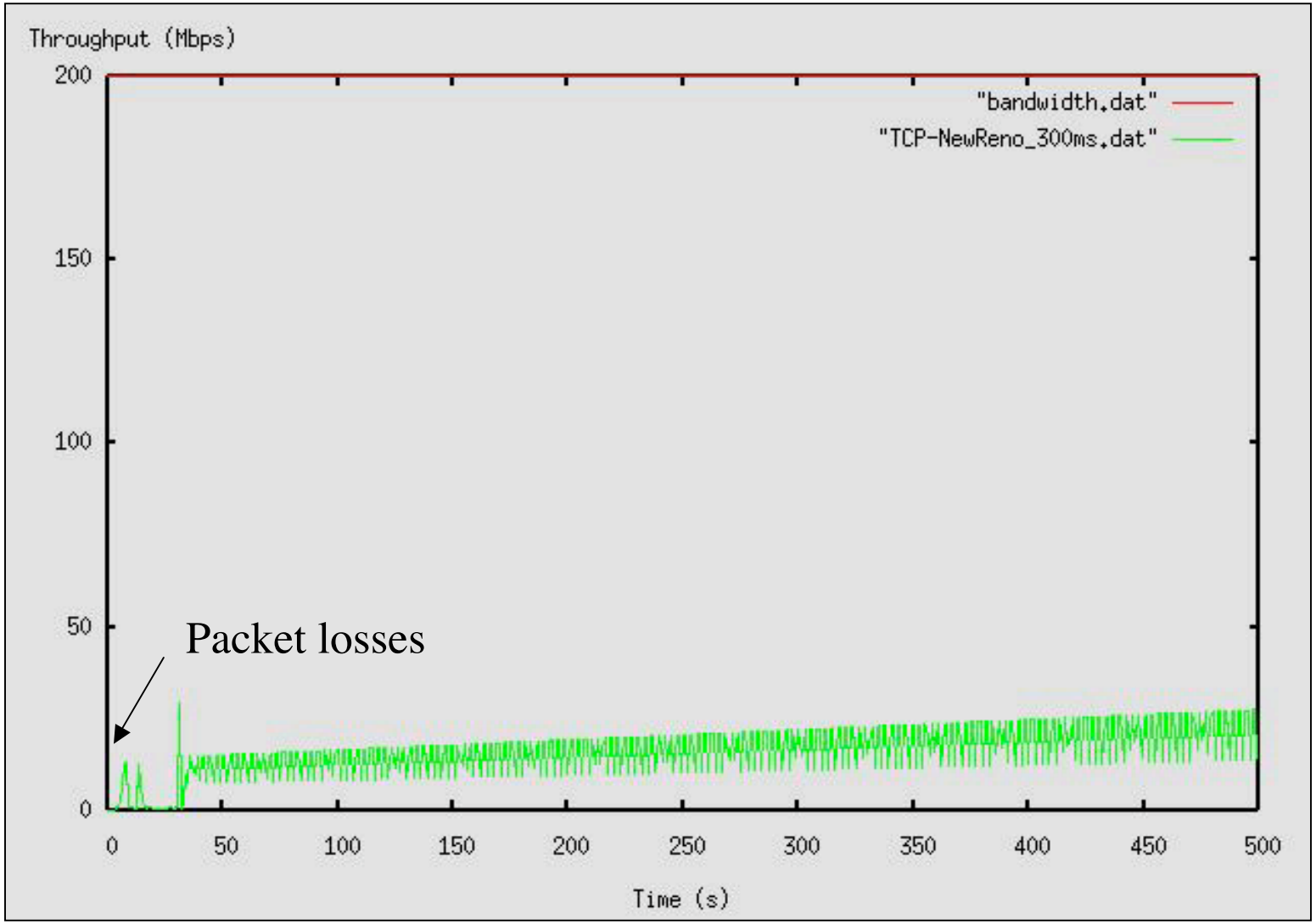

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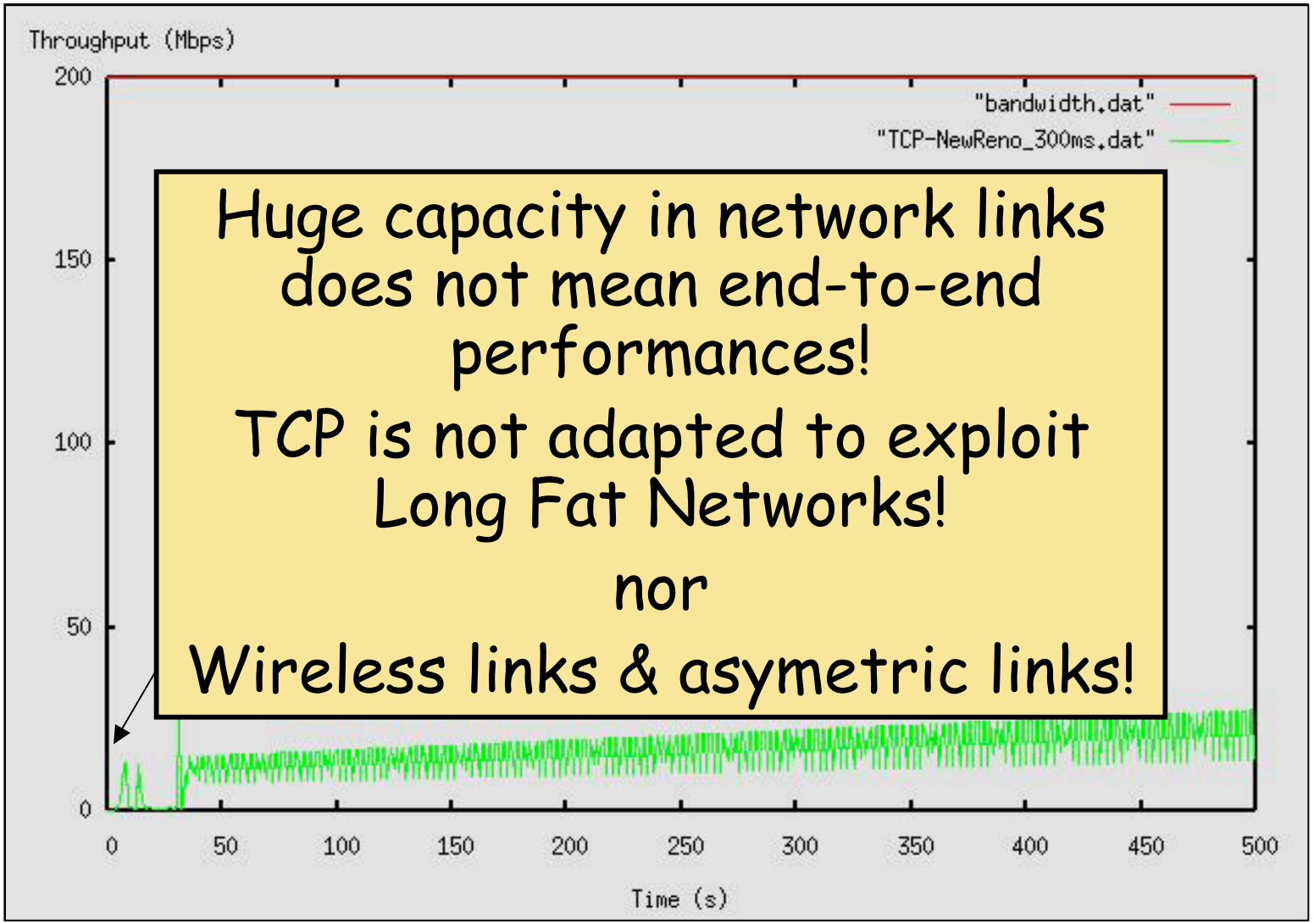
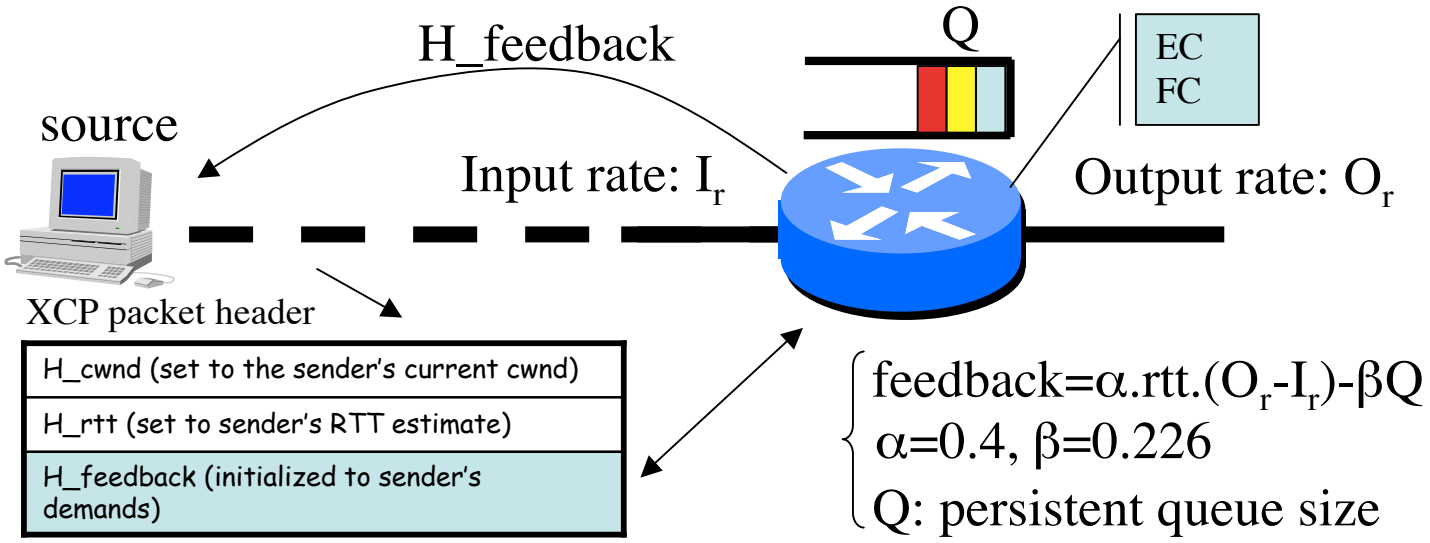


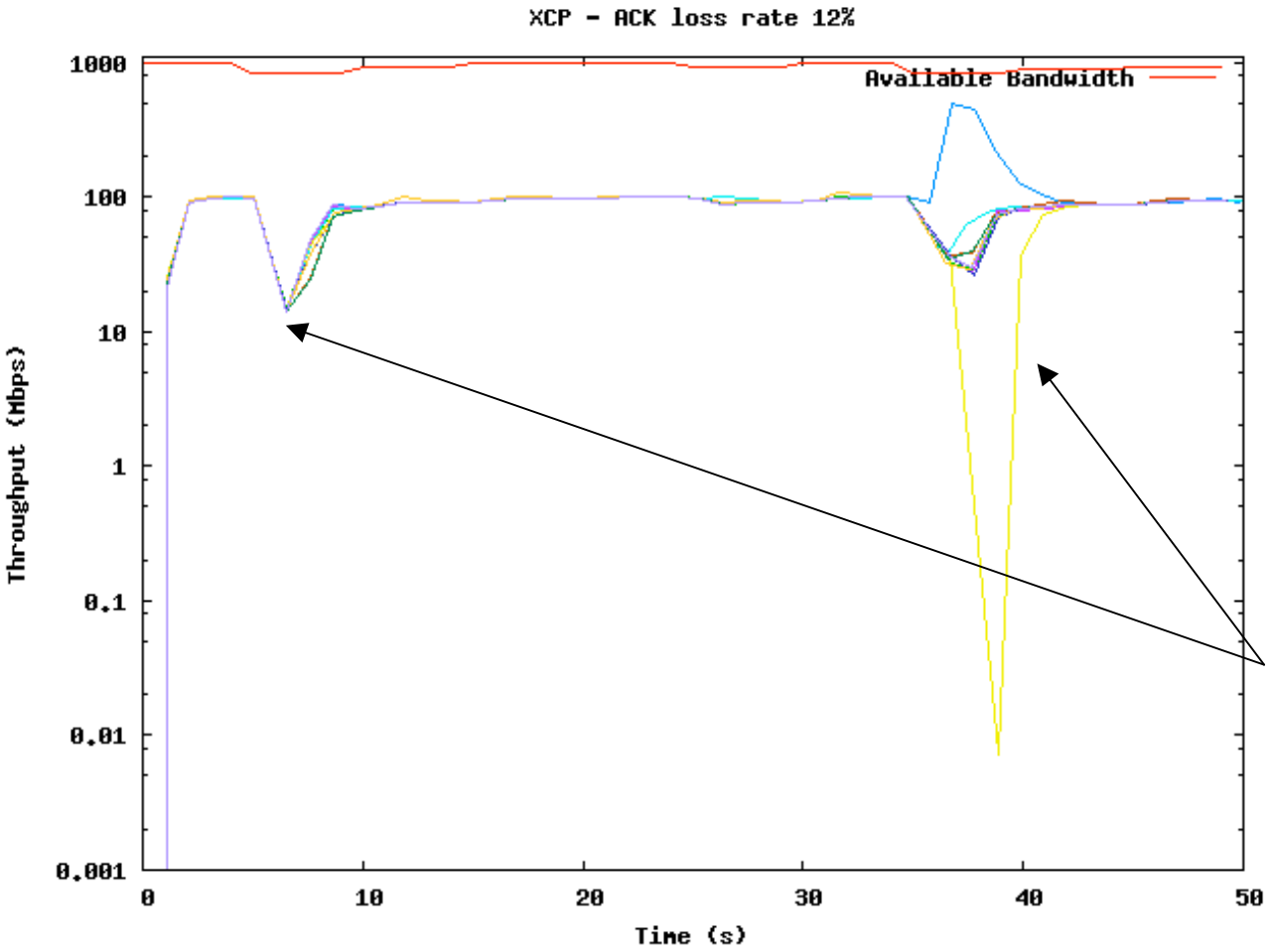
XCP [Katabi02]

- XCP is a router-assisted solution, generalized the ECN concepts (FR, TCP-ECN)
- XCP routers can compute the available bandwidth by monitoring the input rate and the output rate
- Feedback is sent back to the source in special fields of the packet header



XCP-r [Pacheco&Pham05]

A more robust version of XCP



10 flows sharing a 1Gbps link

Fast recovery after the timeouts and better fairness level

Conclusions

- SUSTAINABLE DEVELOPMENT AND INTERNET: SAME BATTLE?
- YES!
- Optimize resource utilization
- Use local resources, local information
- More intelligence rather than more capacity!
- Revisit the end-to-end arguments!