Two Systems to Restructure Mobile Wireless Services

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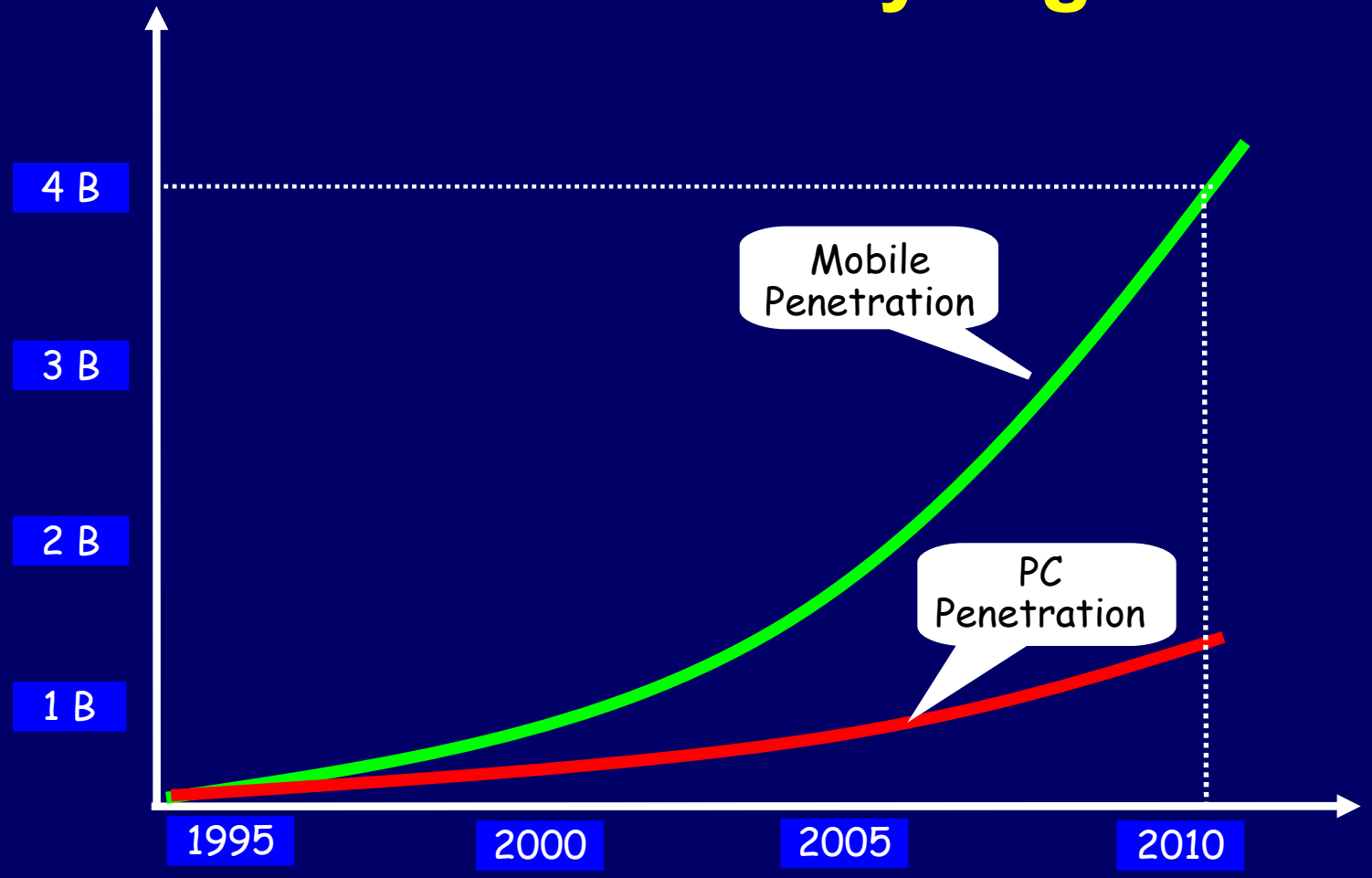
Mobiles vs PCs as Primary Digital Device



Paradigm shift with Mobile Computing

India/China Calling…

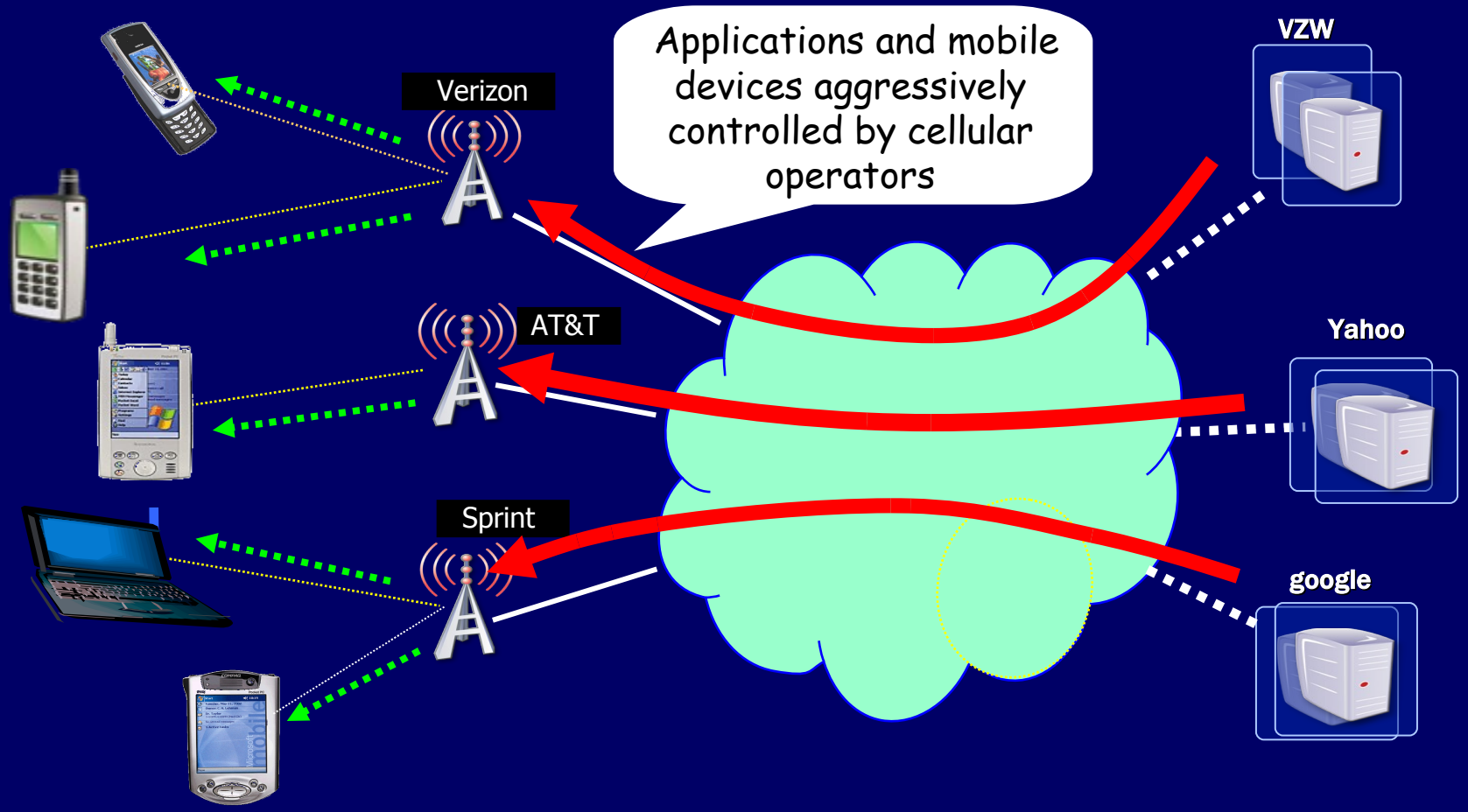
Where do you think 4+ Billion mobile users would be?

Two new directions

- **How to enable an 'open' mobile ecosystem?**
  - MoB System Architecture
  - User reputation and financial incentive mgmt.
  - Application evaluation
- **How to restructure voice-centric mobile networks to support Video?**
  - MobiStream System
  - Virtual Channels
  - Perceptual Slice-structured Video

BUY-1-GET-1-FREE Mobile Operators

Today's (Closed) Mobile Architecture



No (fine-grained) Competition. No Choice. Lack of Innovation.

Why ‘Open’ Closed Networks?

InfoWorld

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Explore 'skype+fcc' in InfoWorld Power Search

Skype asks FCC to force open mobile networks

Letting any device connect to cellular networks would give consumers a wide range of choices

By Stephen Lawson, IDG News Service
February 26, 2007

E-mail | Printer Friendly | Reprints | Text Size A A

ARTICLE TOOLS SPONSORED BY hp

Skype is looking to a 1968 ruling by the U.S. Federal Communications Commission to open up the country's mobile phone industry for "unlocked" devices and third-party applications -- such as Skype.

Foster Innovation. Respect Users’ Choice.
Enable (fine-grained) Competition.

Fundamental Design Principles

Decouple infra providers from services providers

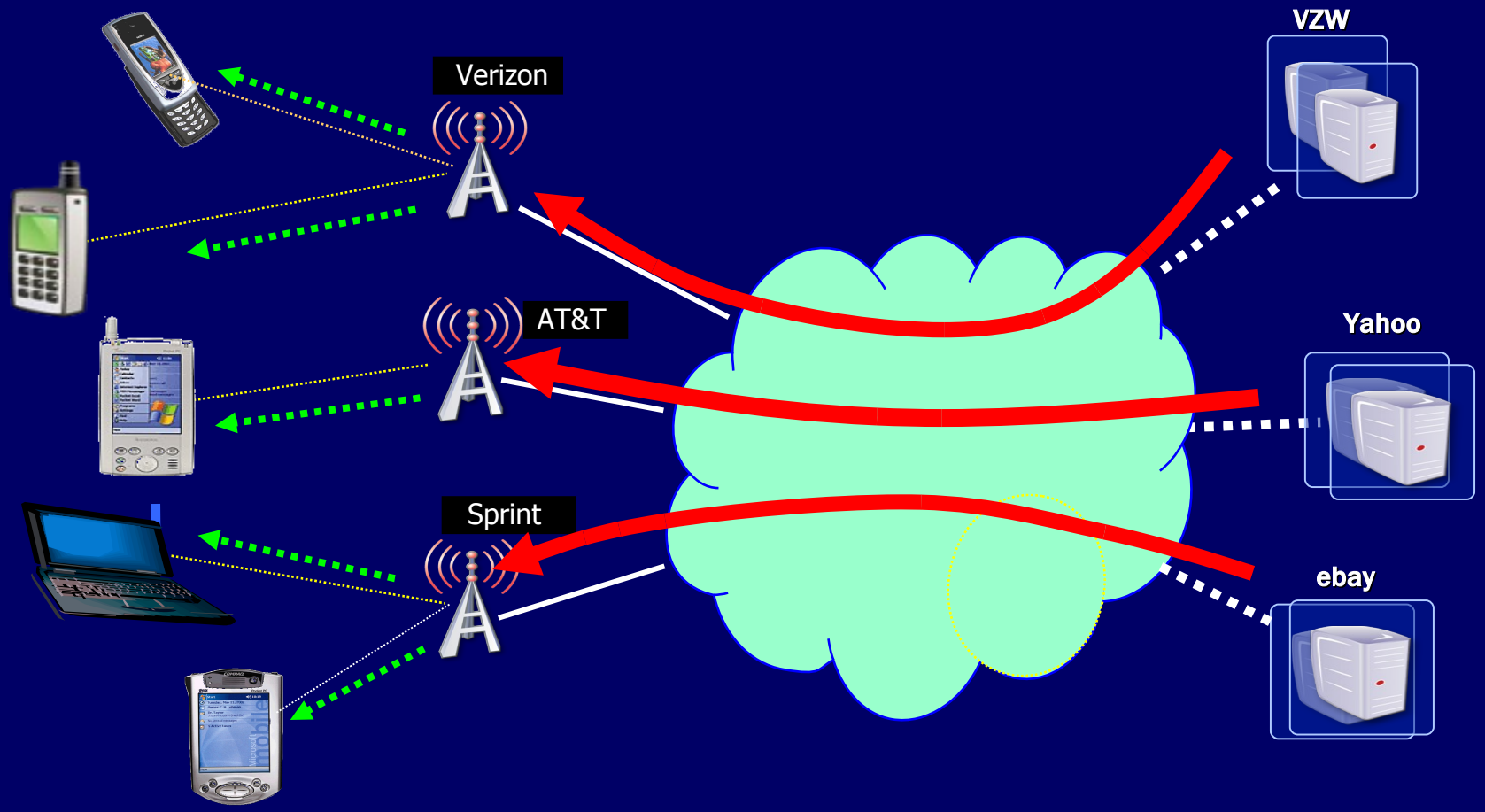
Allow service interactions on arbitrary timescales

Enable flexible composition of service interactions

ACT 1996 Restructured US telecom

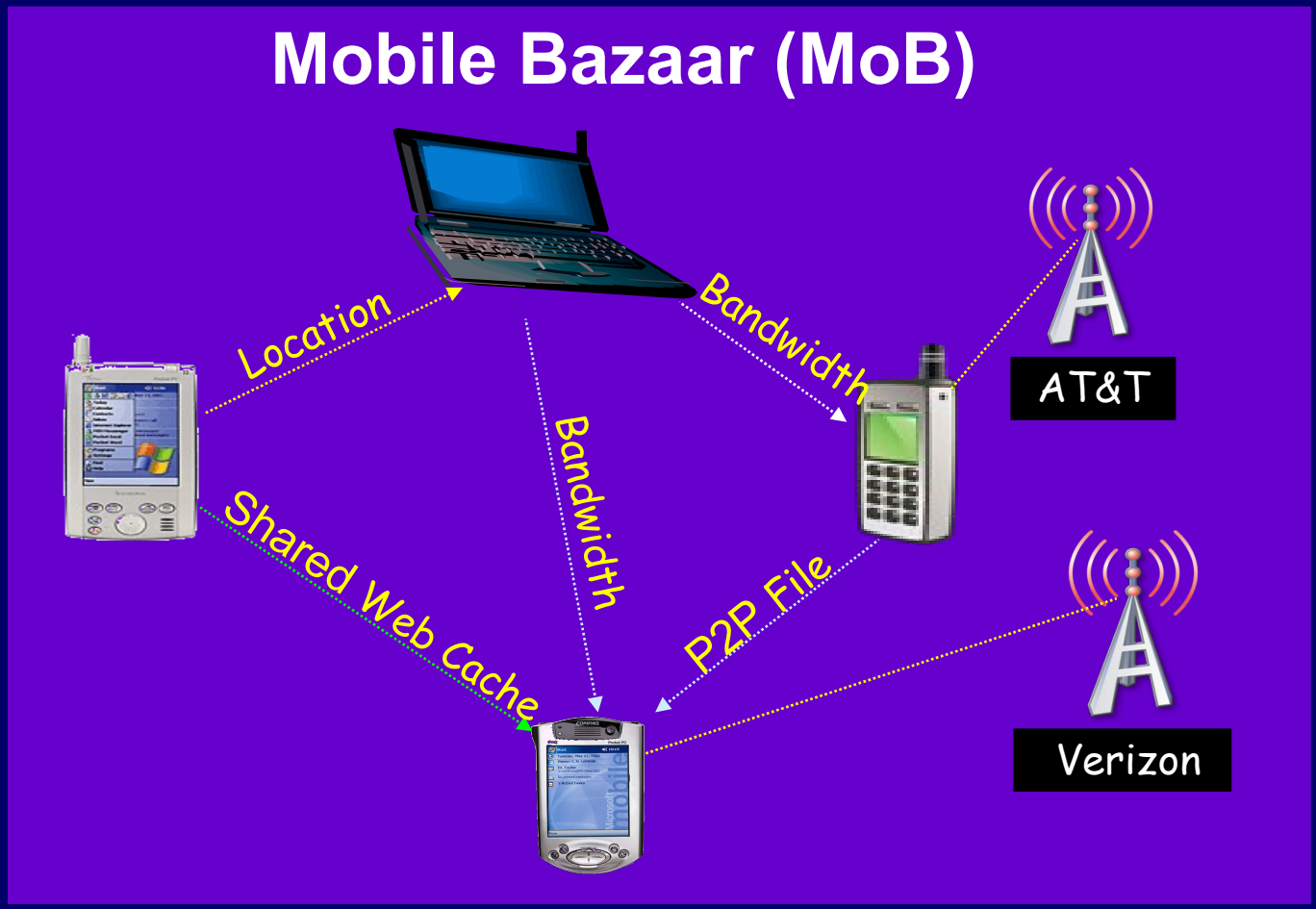
Recall that restructuring enabled fine-grained competition for telecom products & services

Today's (Closed) Architecture



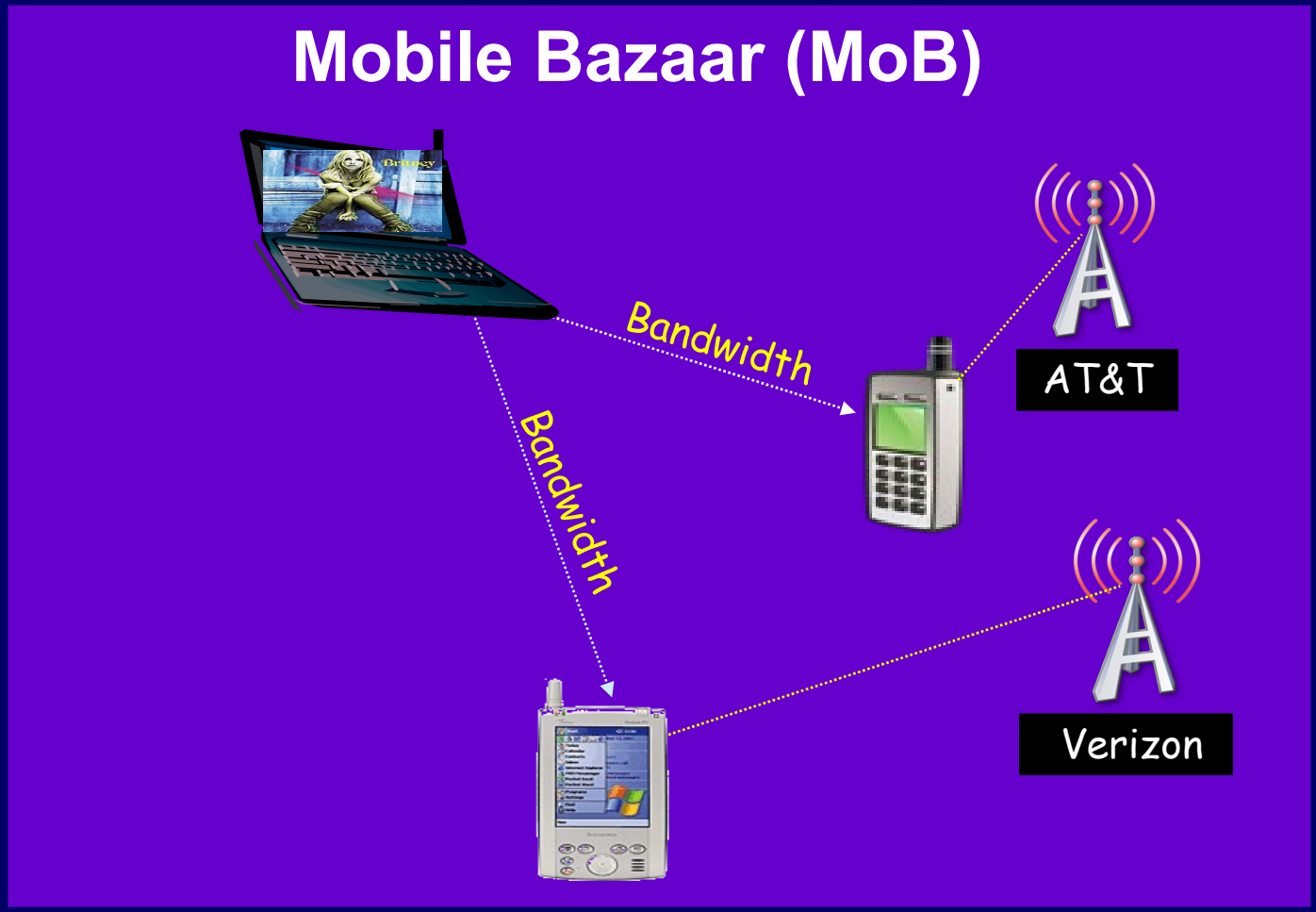
No User Choice. Lack of Innovation.
No (fine-grained) Competition.

Tomorrow's Open Mobile Architecture



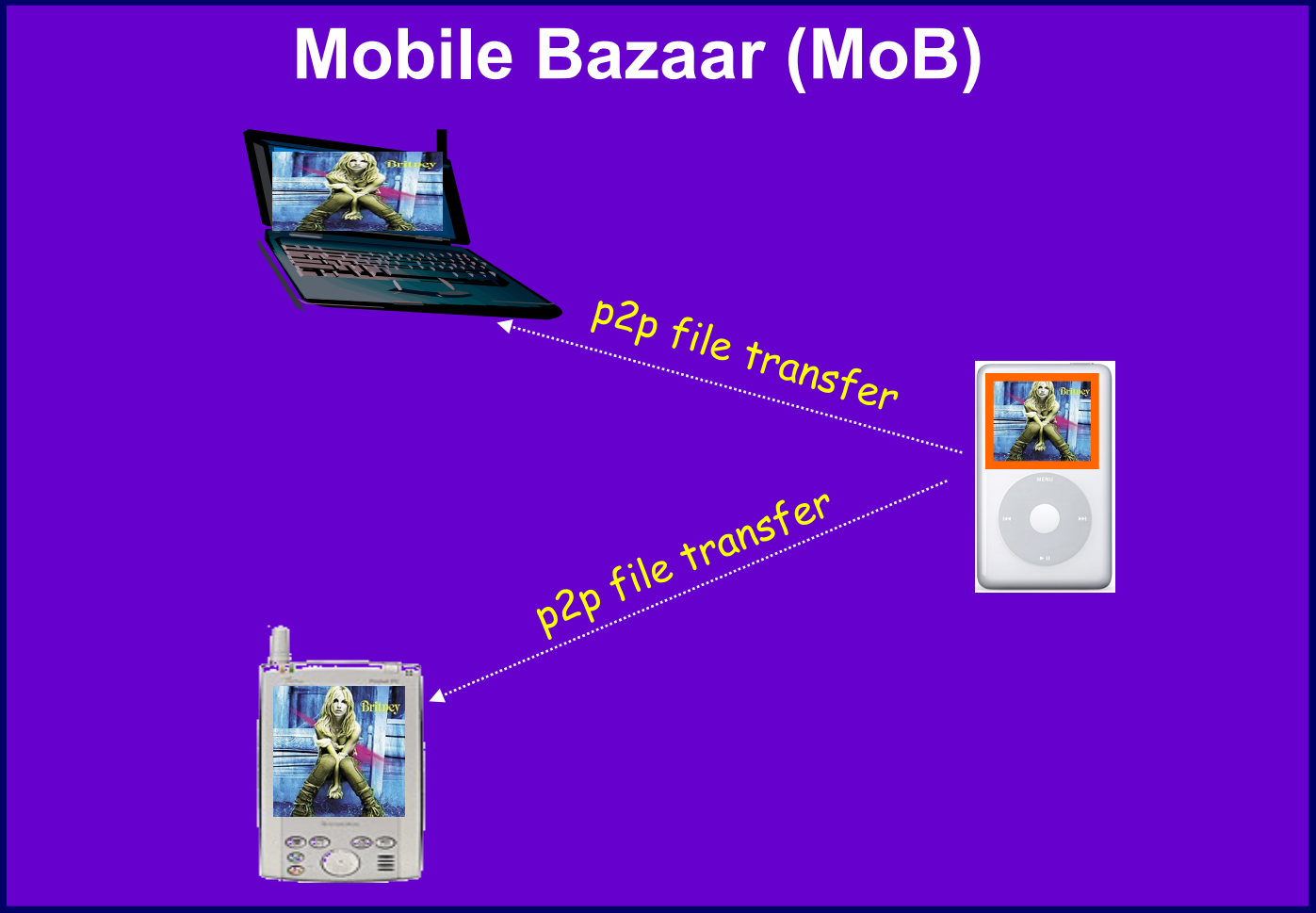
Mobile devices can independently create and sell services (aka 'open' market model)

Scenario #1: Bandwidth Aggregation



Enables distributed wireless diversity decisions with mobile users/devices

Scenario #2: P2P file transfer service



Enables flexible customization of services based on user or app needs (disconnected mode)

Scenario #3: Opportunistic Services

Mobile Bazaar (MoB)

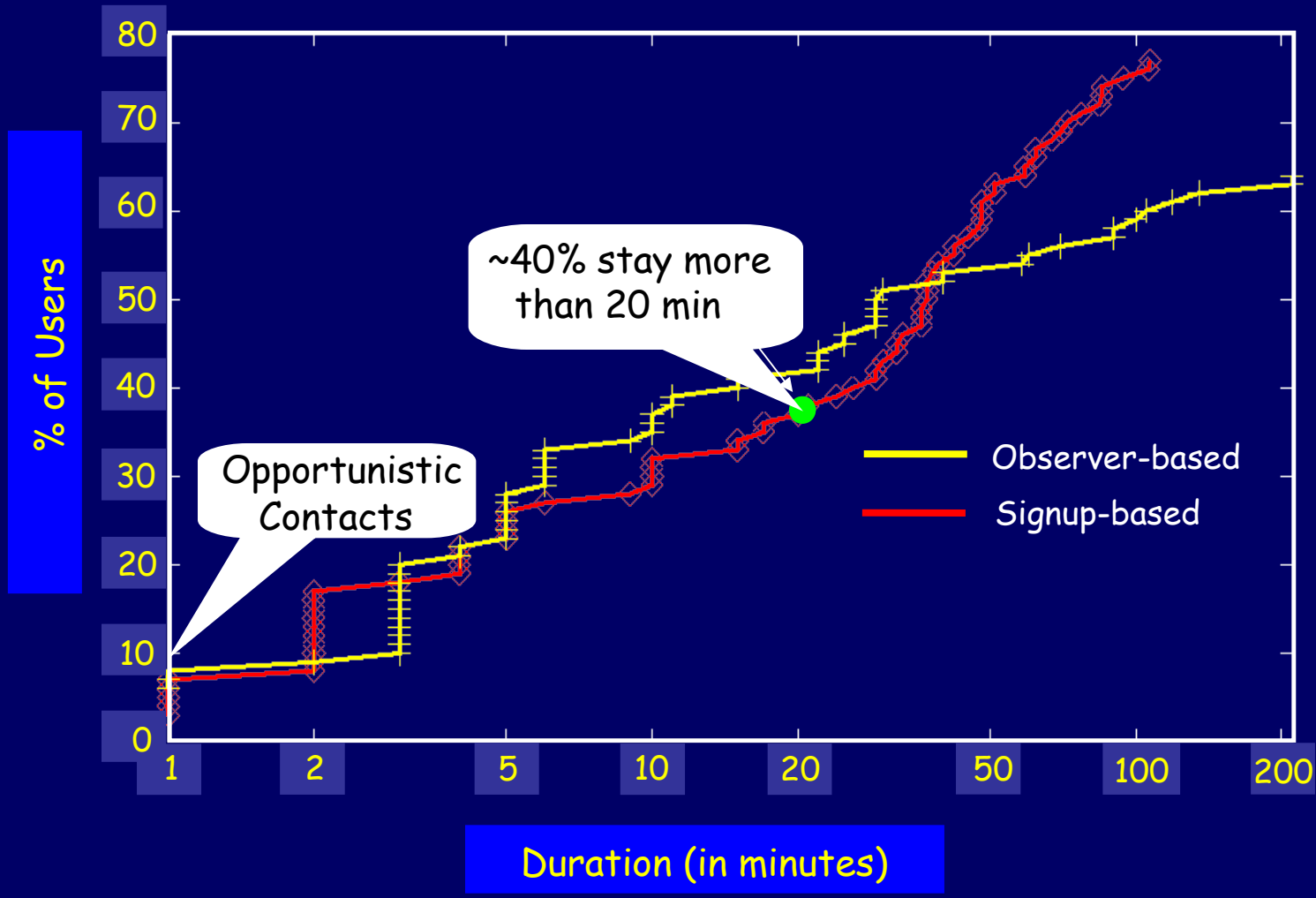
Enables opportunistic time-scale service interactions (disconnected mode)

The MoB Advantage

- **Better Performance thru Wireless Diversity**
  - Network Diversity
  - Channel Diversity
  - Technology Diversity
- **Financial incentive for Collaborations**
  - Enables flexible, application-level service trades
- **Flexible customization of services**
  - Users choose services based on price, signal, location, etc.

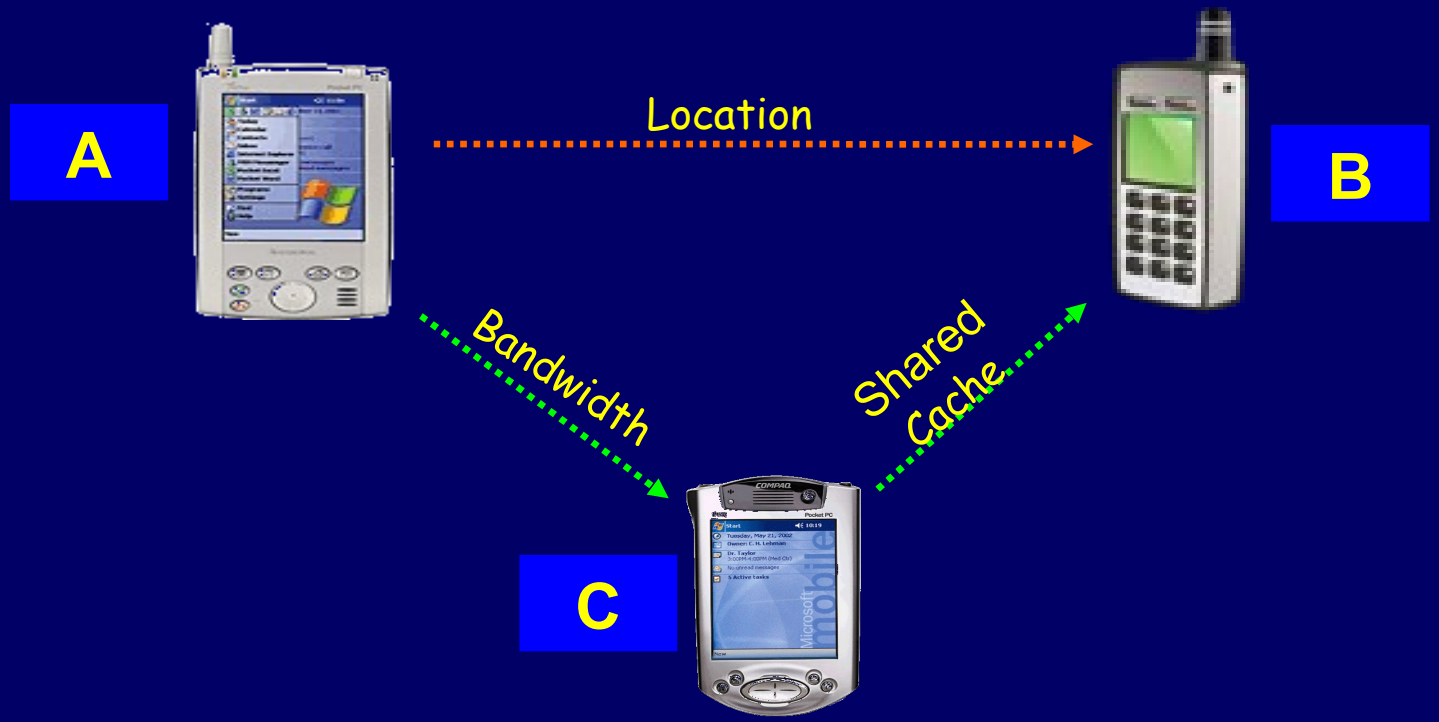
What are MoB environments?

MoB Contact time is Variable



Application-layer Services in MoB

- Hop-by-hop "pair-wise" service interactions

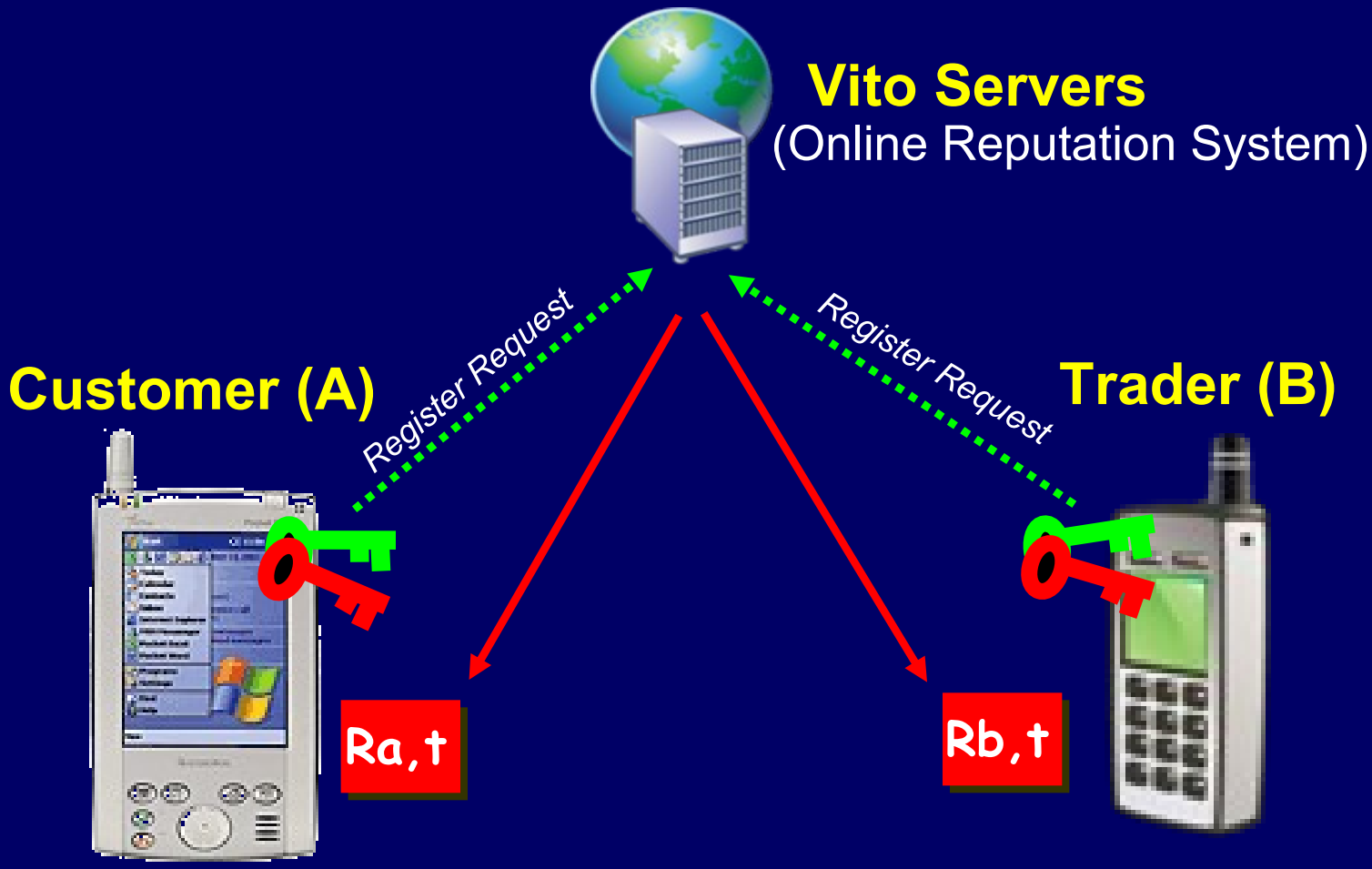


How can A be made to trust B, or trust C?

Vito – Building trust thru Reputation

- Vito modeled on ebay
- 3rd Party Internet service
- 4 million transactions/day
- Misuse rate very low

Step 1 – Devices register using key-pairs

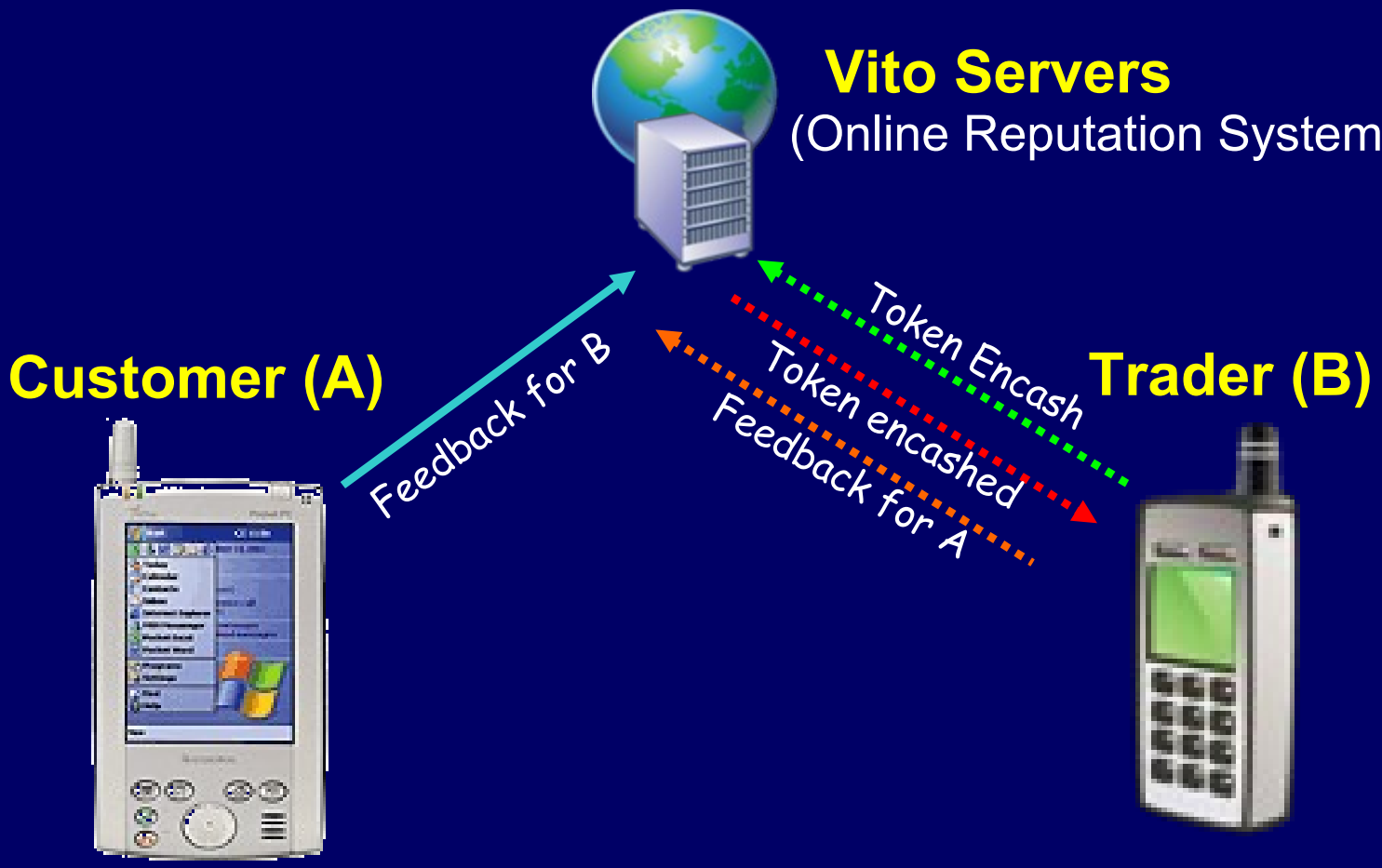


Devices receive signed time-stamp reputation cert. (online registration with public key)

Step 2 – Service Interaction and Payment

Customer makes payment first to receive service (Disconnected — No Vito during interaction)

Step 3 – Token Encash and Feedback



Customer provides feedback only if dissatisfied

Step 4 – Reputation Updates at Night

Vito Servers
(Online Reputation System)

Customer (A)

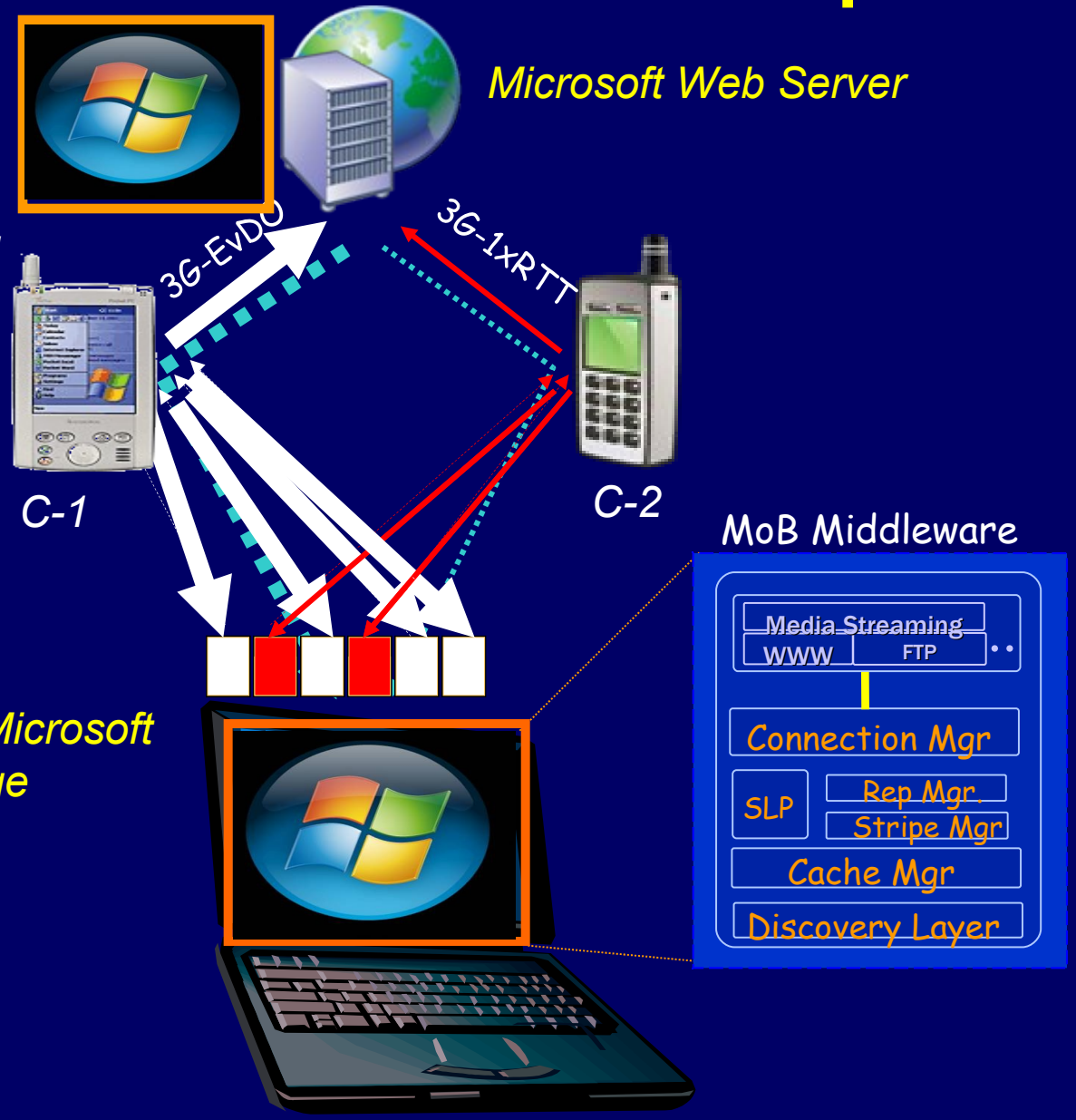
$R_{a,t}$

$R_{b,t}$

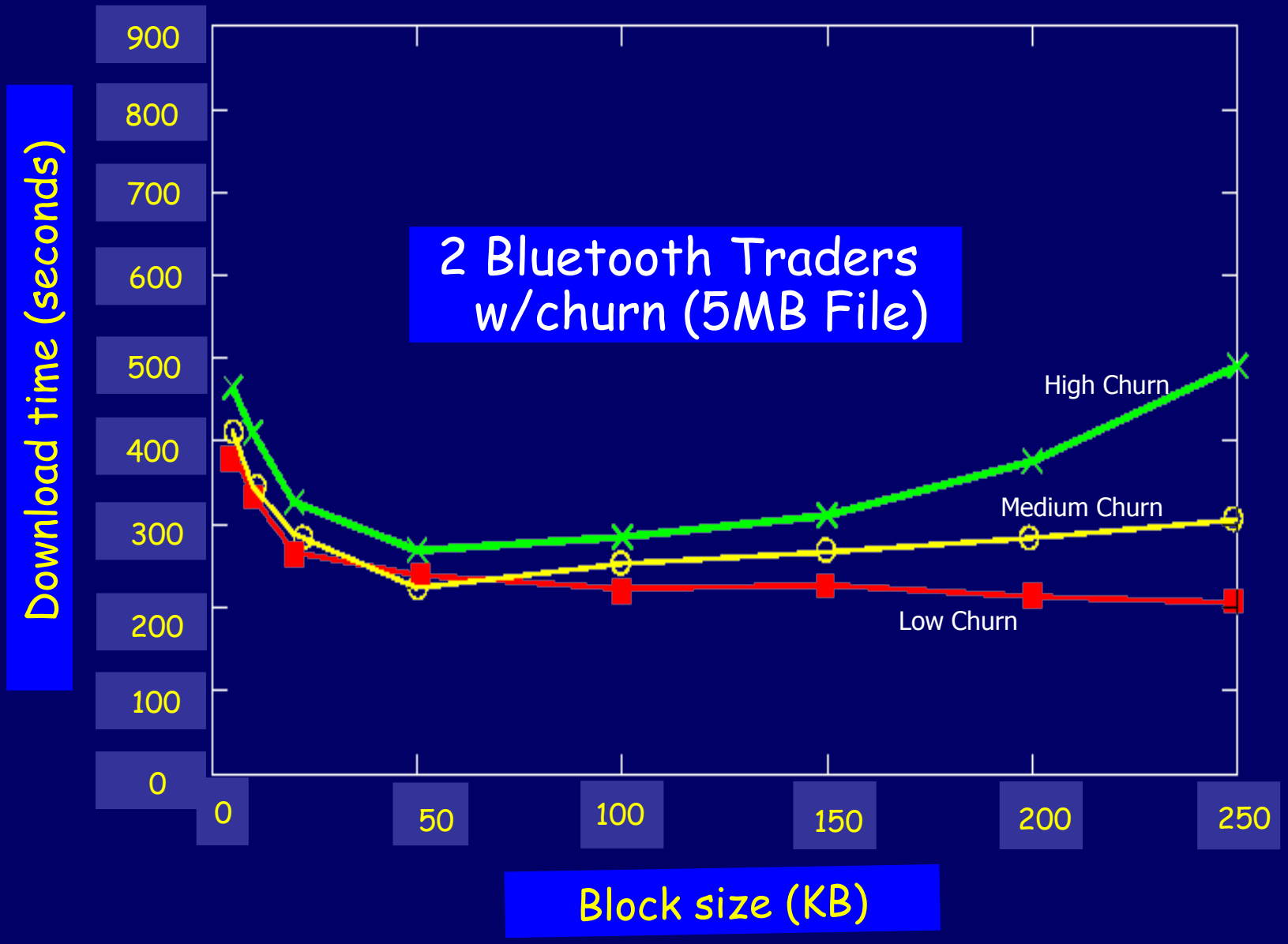
Trader (B)

A small transaction fee is the incentive for Vito

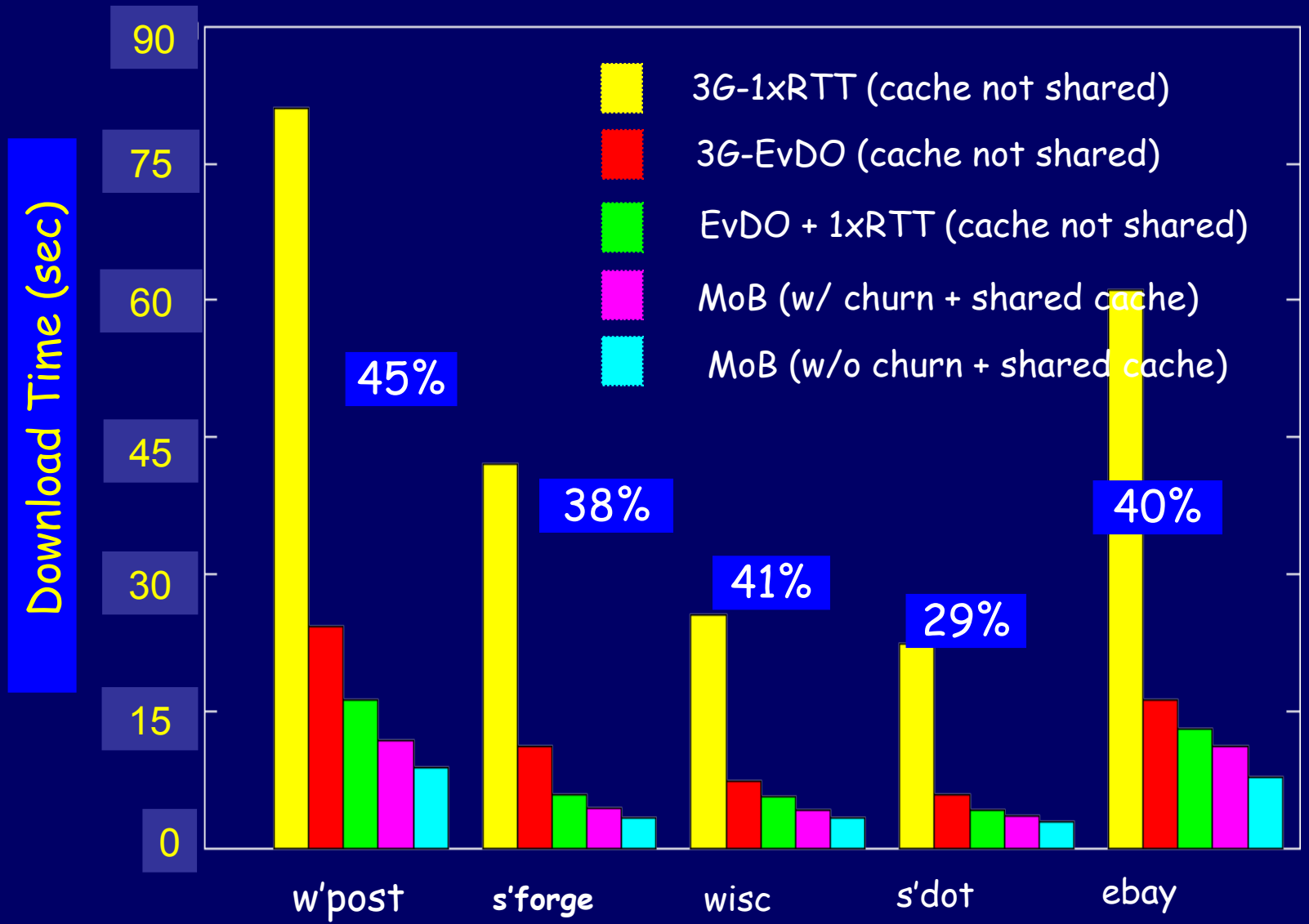
Remote file download example



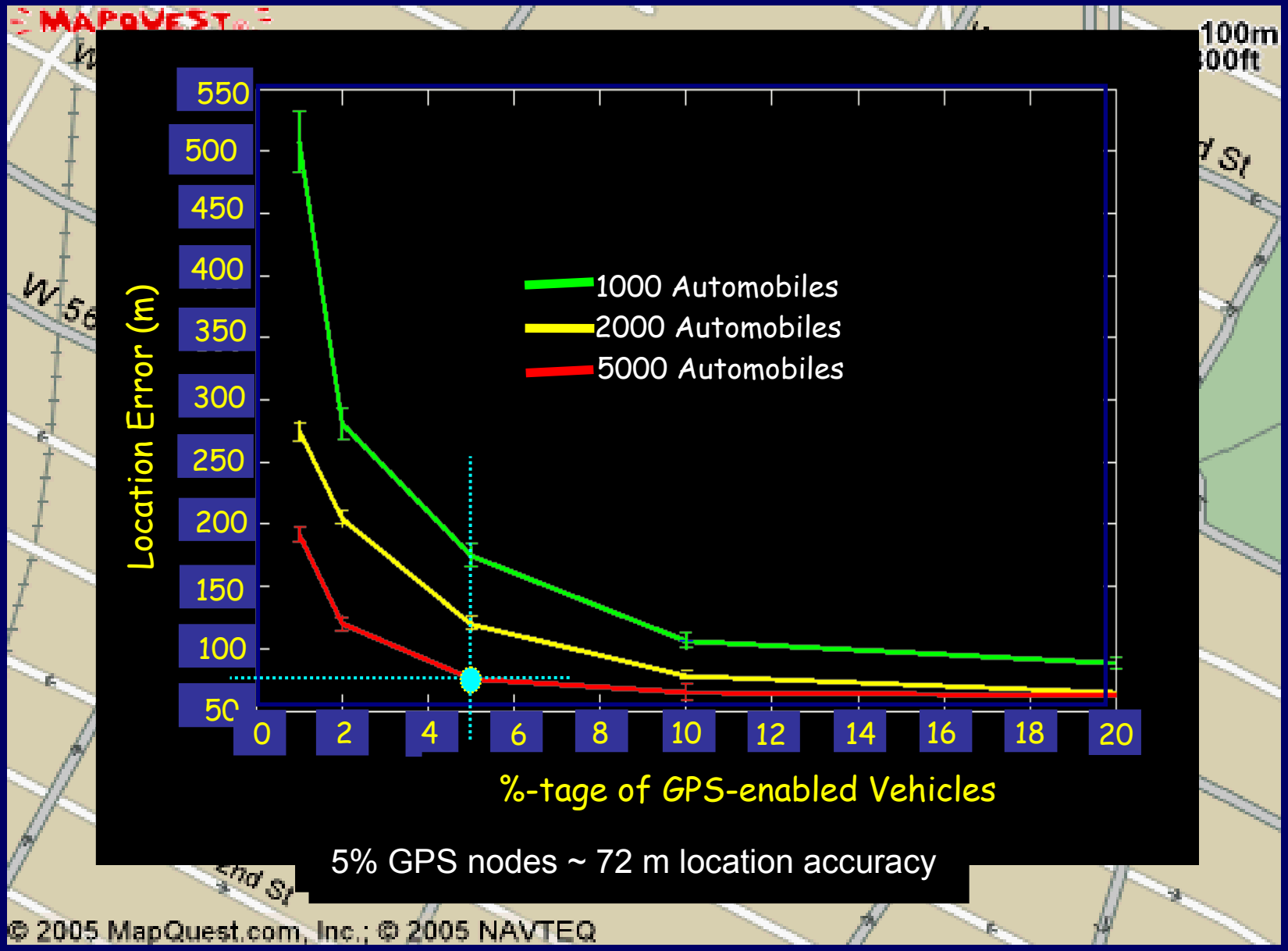
P2P file transfer (testbed)



Collaborative Web Browsing (testbed)



Opportunistic location (simulation)



Fundamental Contributions of MoB

(ACM Mobicom'05)

Decouples infra providers from services providers

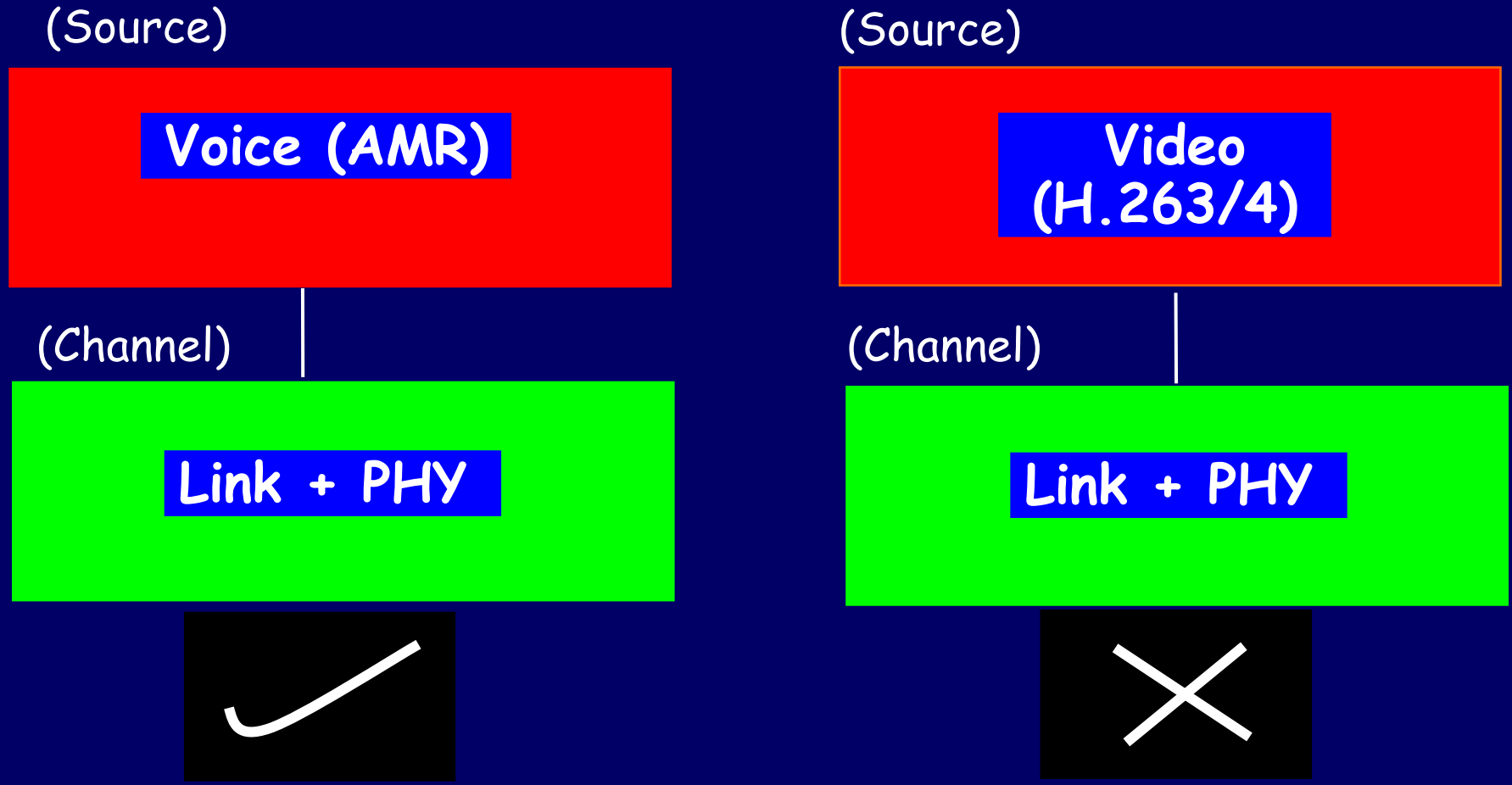
Allows service interactions on arbitrary timescales

Enables flexible composition of service interactions

Is Mobile Video ready for prime-time?

There are challenges…

What is the fundamental issue with 2.5G + 3G Mobile Networks?

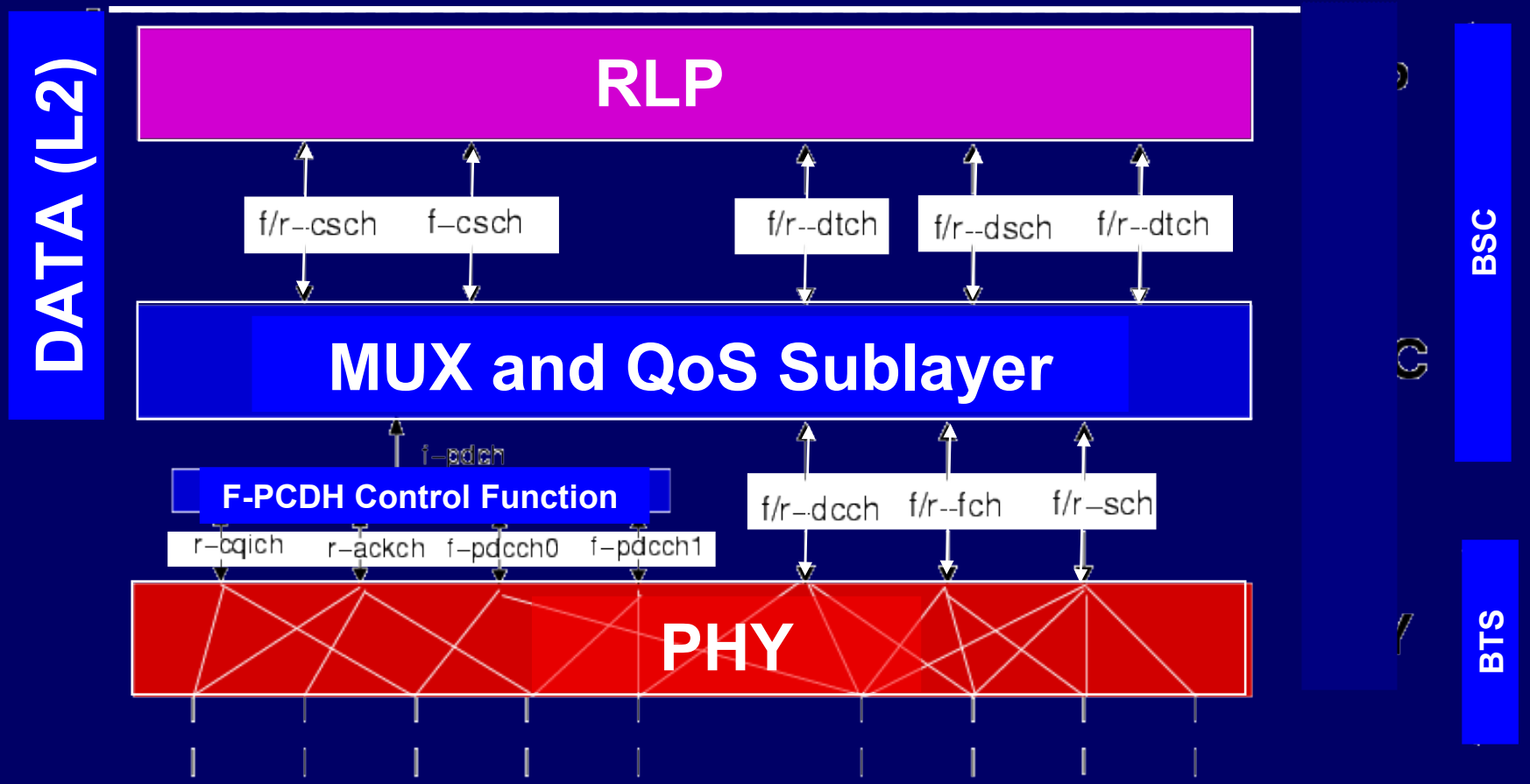


Source-channel optimized

Source-channel Not Optimized

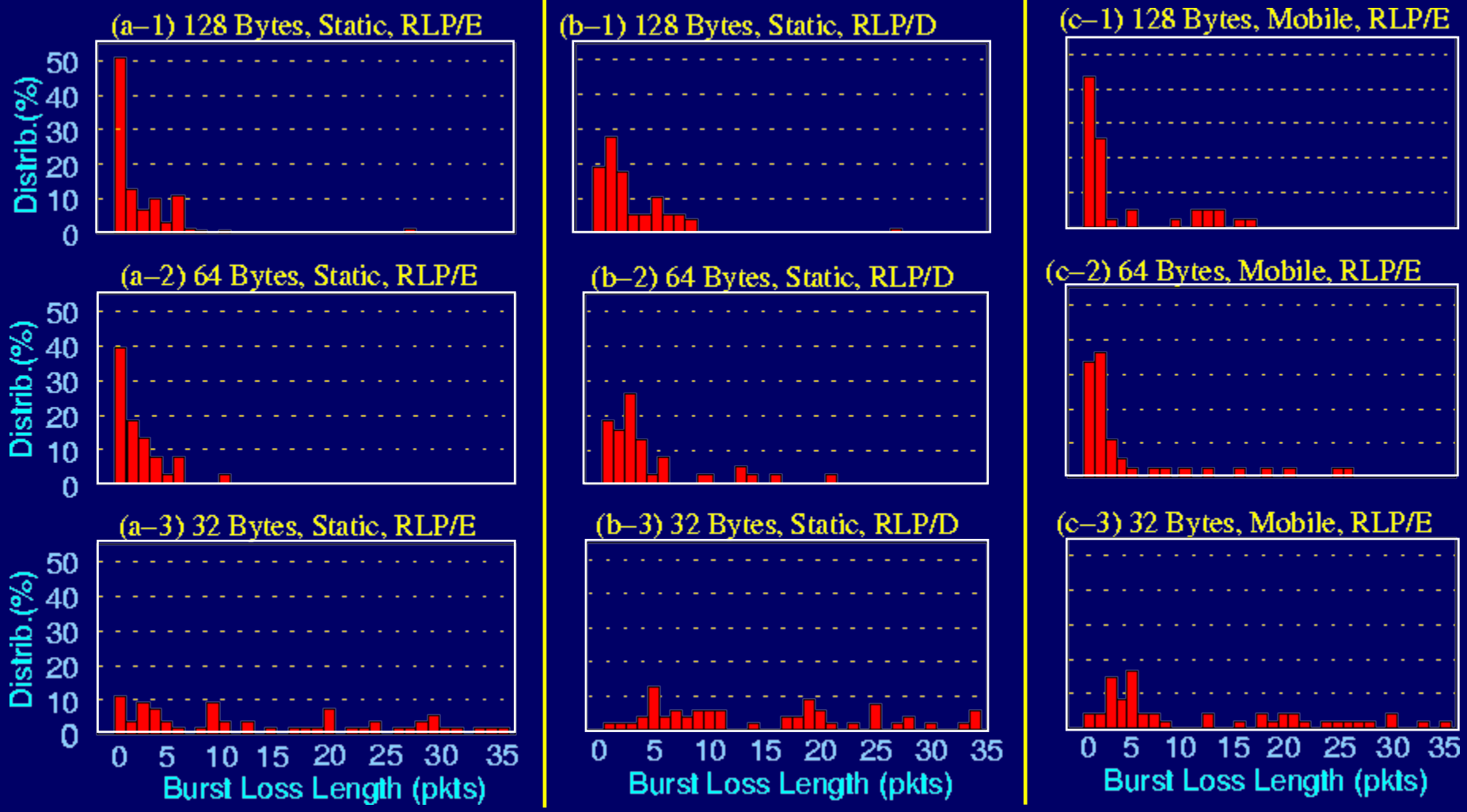
Today's Mobile Networks engineered for Voice

Mobile Channels are Voice Optimized (e.g., CDMA1xRTT)



Static. Inflexible. No Application Control.

Mobile channels prone to bursty losses

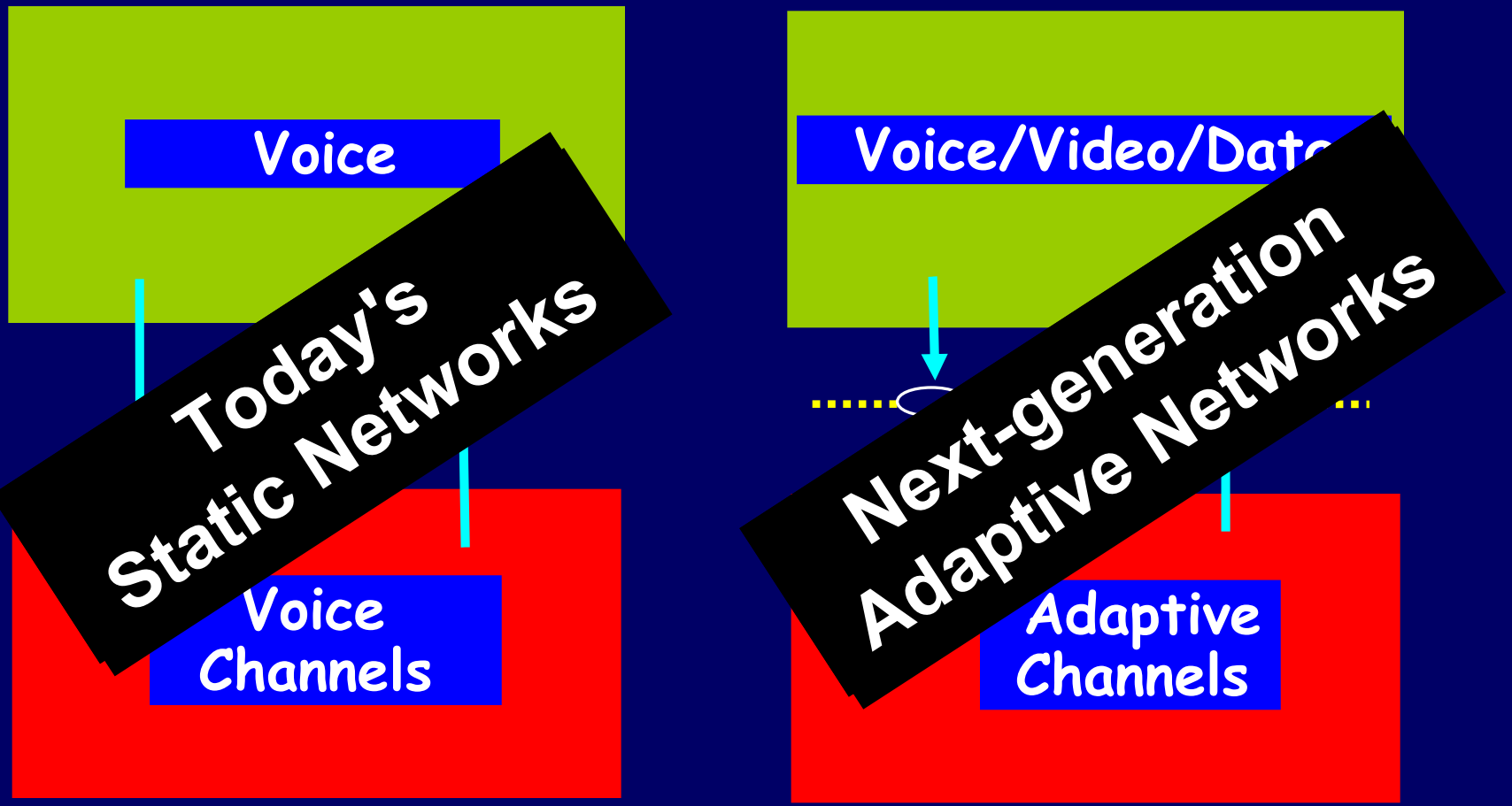


RLP = Enabled (stationary)

RLP = Disabled (stationary)

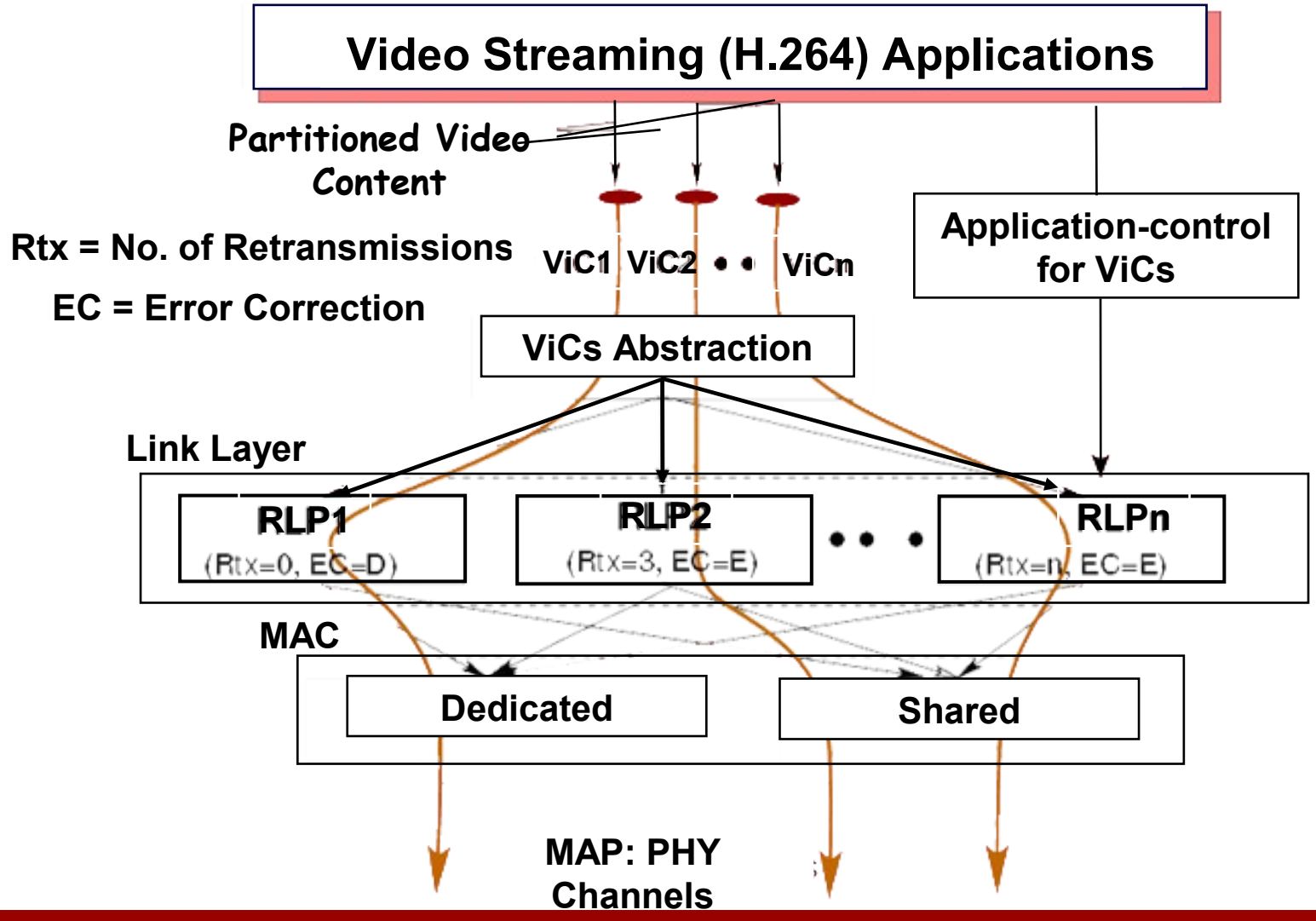
RLP = Enabled (Mobile)

Streaming Video over Voice Channels



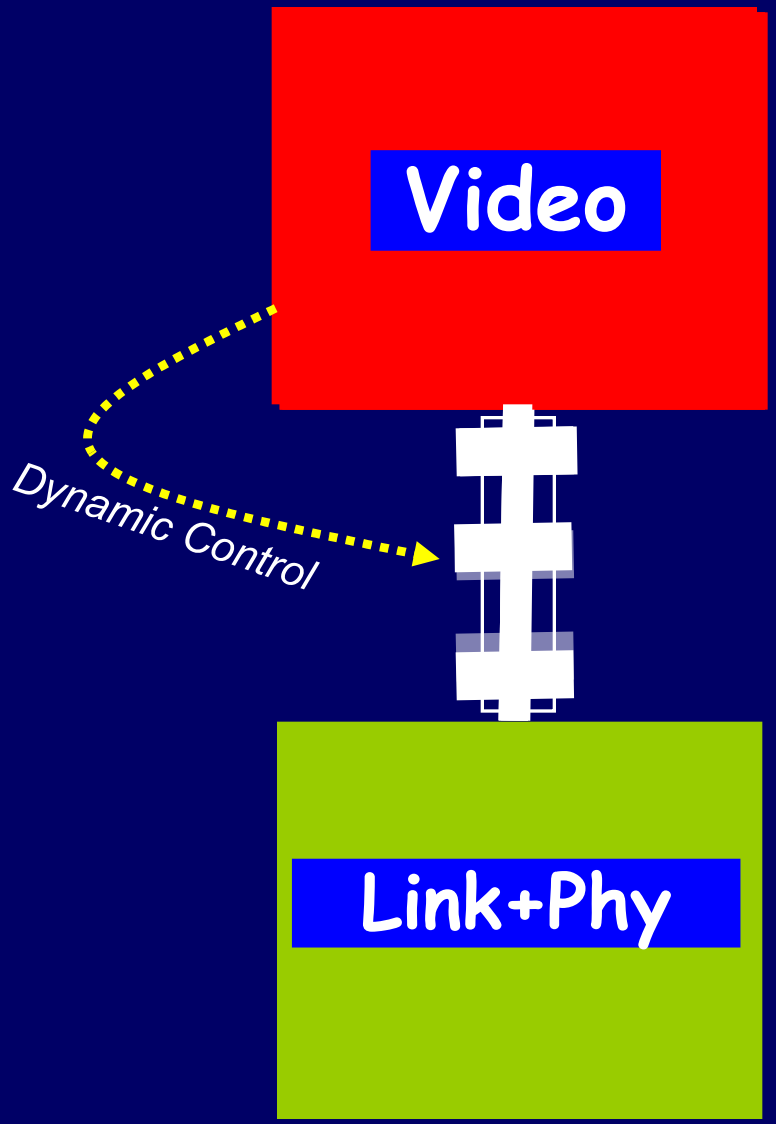
How to design adaptive mobile networks & apps?

Our Solution: The "Virtual Channels" Concept



App-controlled Channels. Dynamic. Flexible.

Dynamic Channel Control – How?

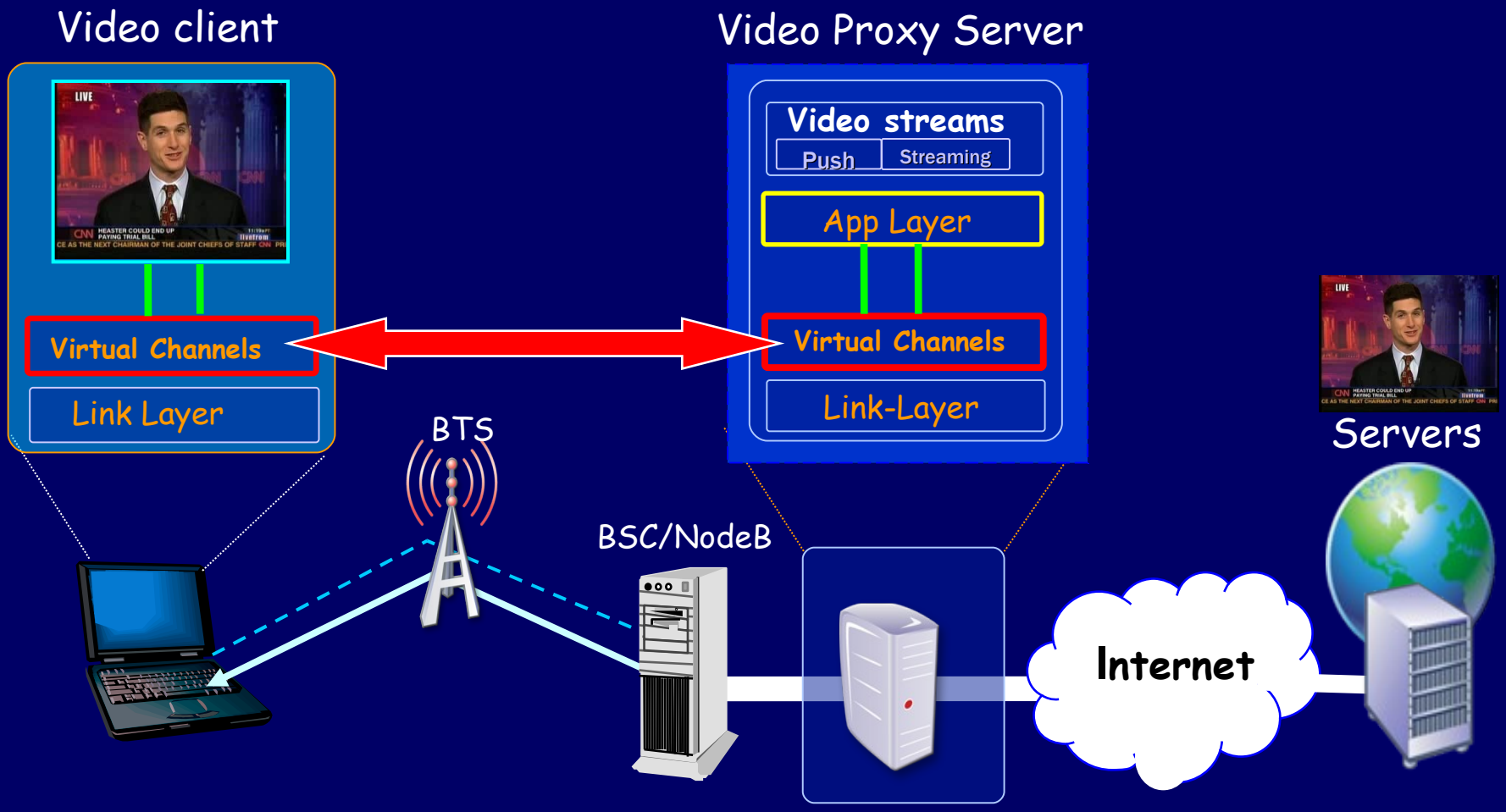


Who takes control?

Think of a Slider.

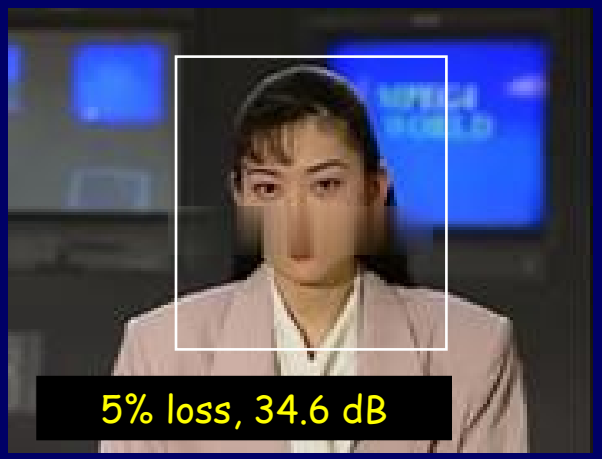
When the slider moves up or down, control of channel shifts between App & Network.

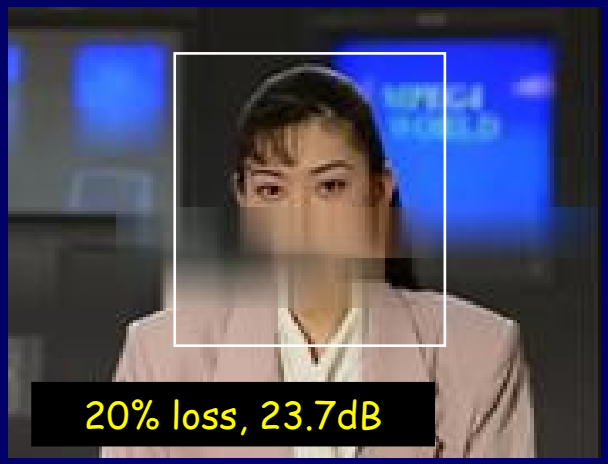
MobiStream – The BIG Picture



How to intelligently stream video over ViCs?

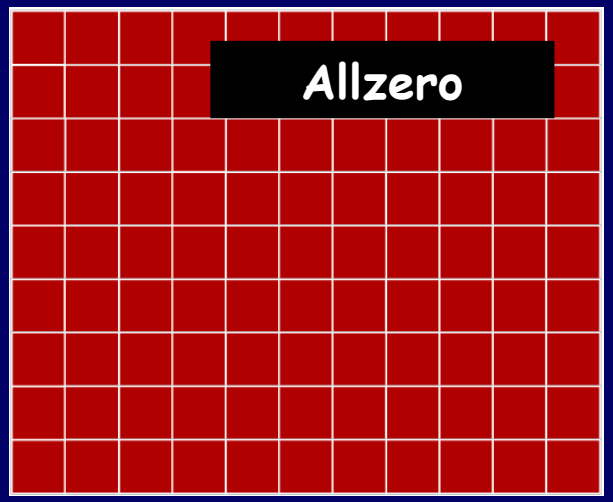
How to design ‘intelligent’ video apps?

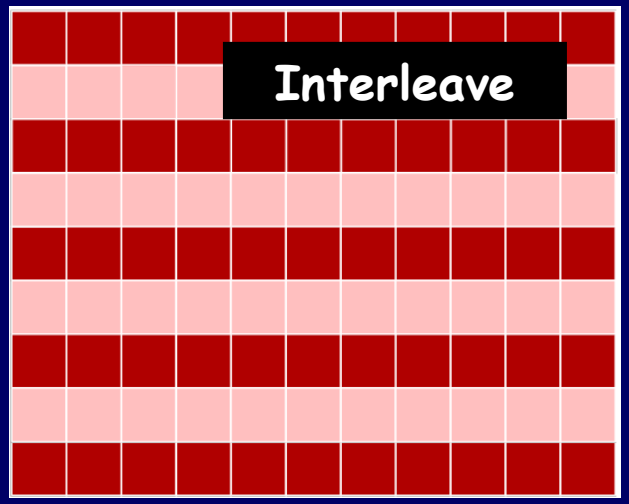


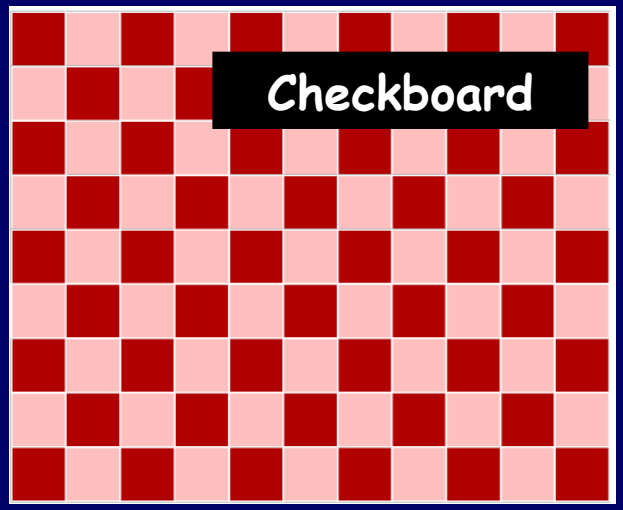


Exploit perceptual value in Video Content

Perceptual Slice-structured Video







ROI

(slice grp-1)

slice grp-2

Specify Region-of-Interest as ‘hints’ in slices

Perceptual Slicing over ViCs

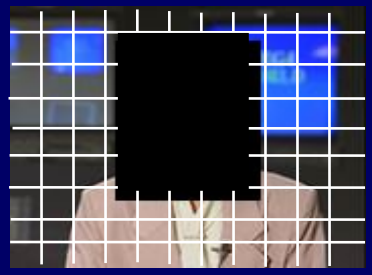
Perceptual Video Codec
(ROI segmented frame)

Slice-1 over ViC-1

ViC-1
(RLP-E)

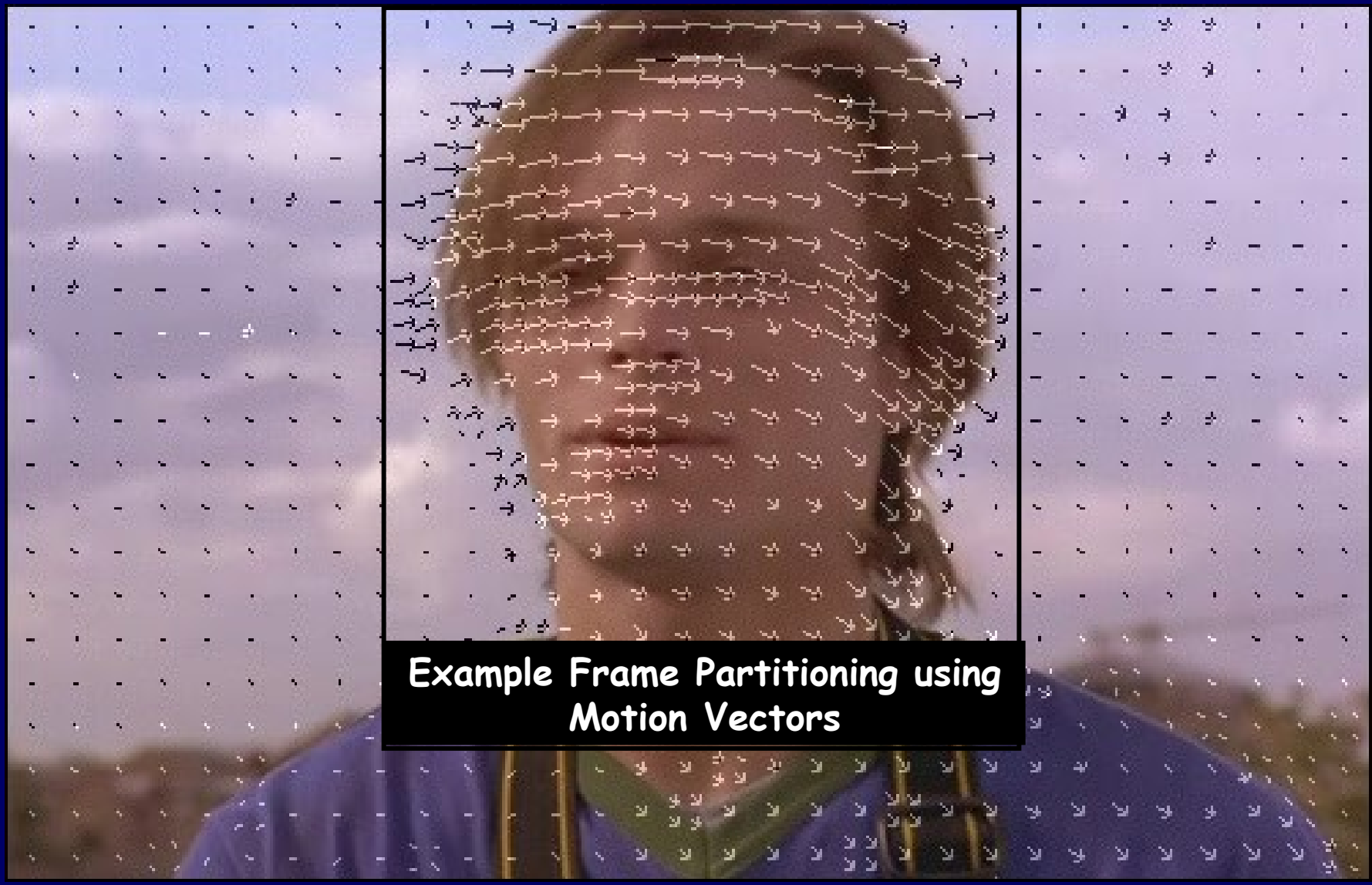
ViC-2
(RLP-D)

Slice-2 over ViC-2



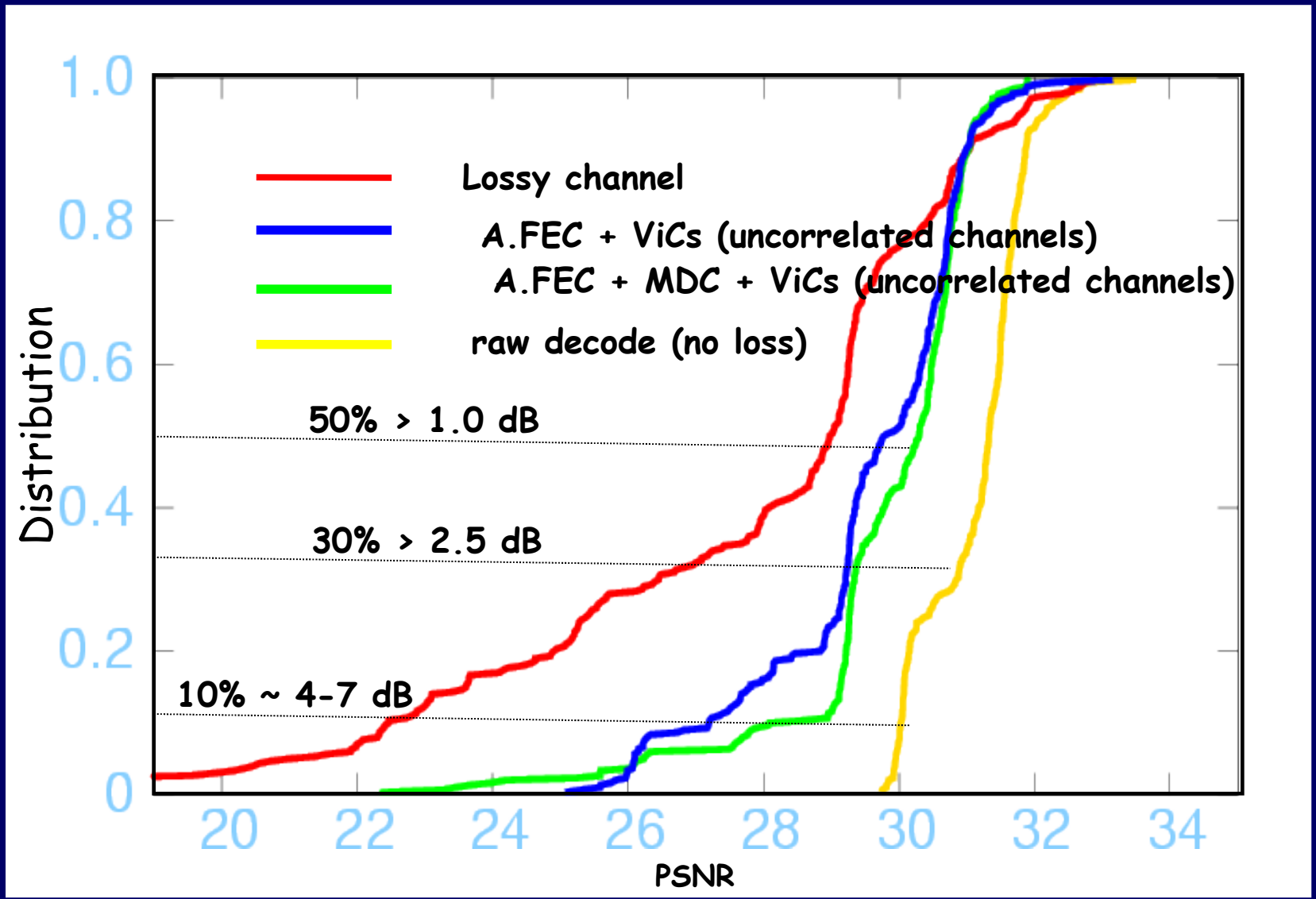
ViCs Abstraction

Cellular Link + PHY Subsystem

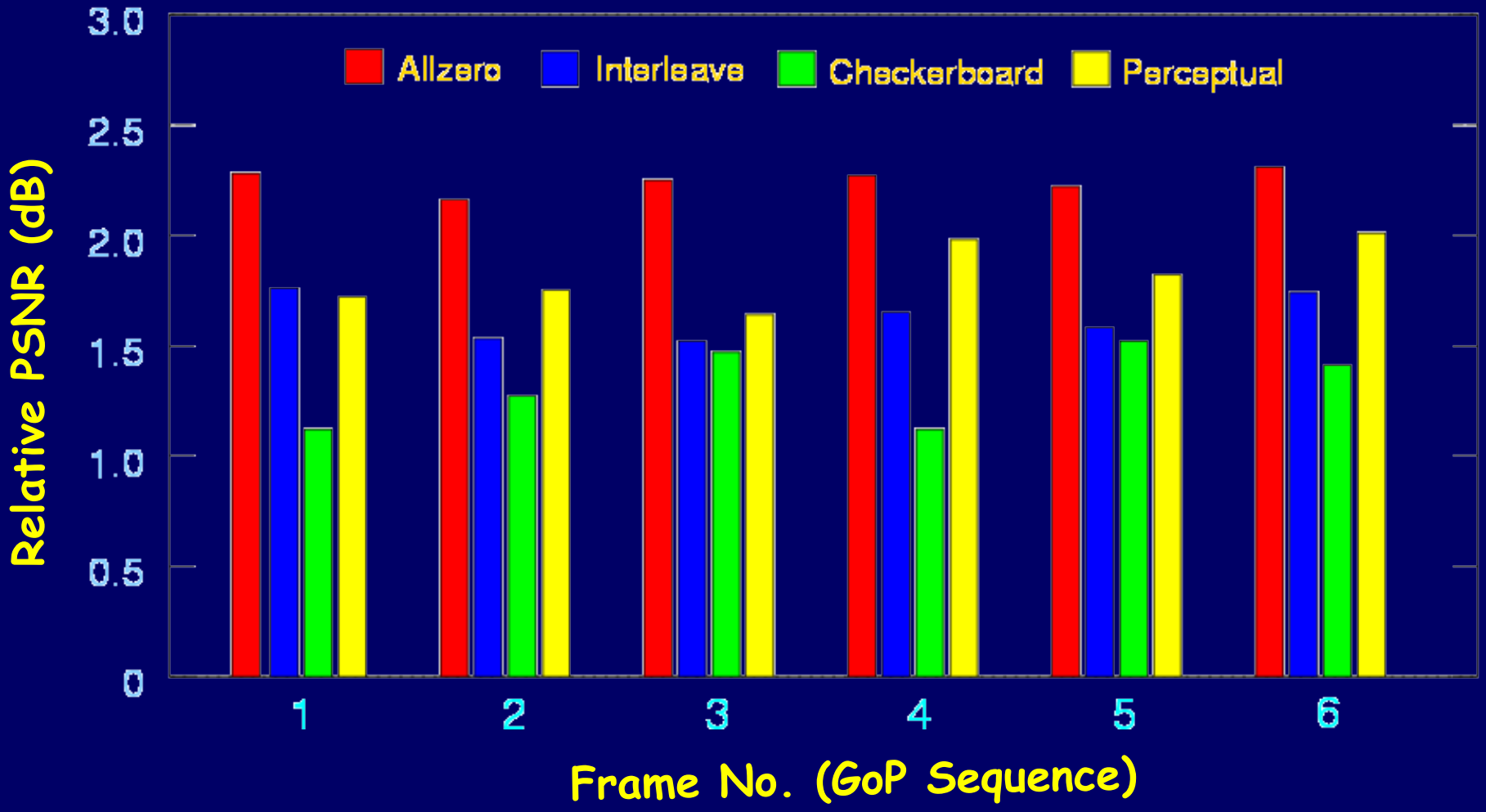


Perceptual codecs may segment frames with MVs

Experimental results for foreman QCIF video seq. (300 frames)



Sliced Video benefit using ViCs

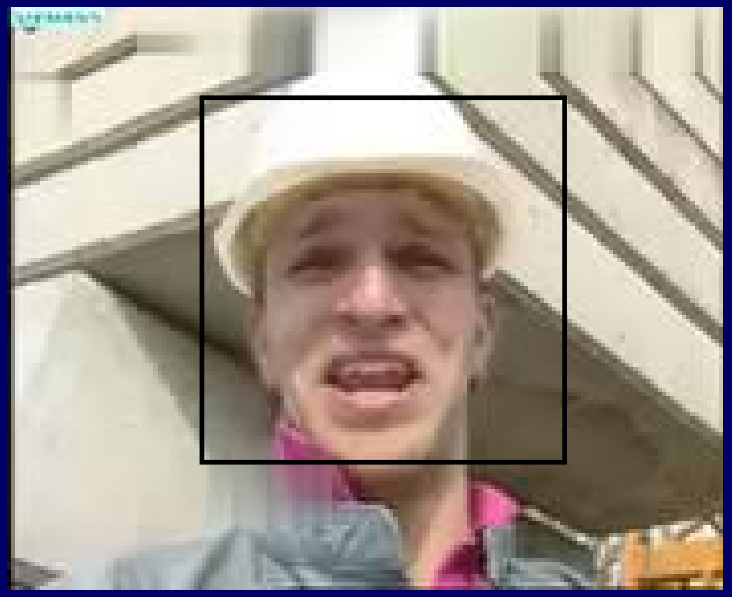


Up to 4 dB benefit using ViCs (Foreman)

Perceptual-SS Improves Subjective Picture Quality

Checkboard

Perceptual-SS

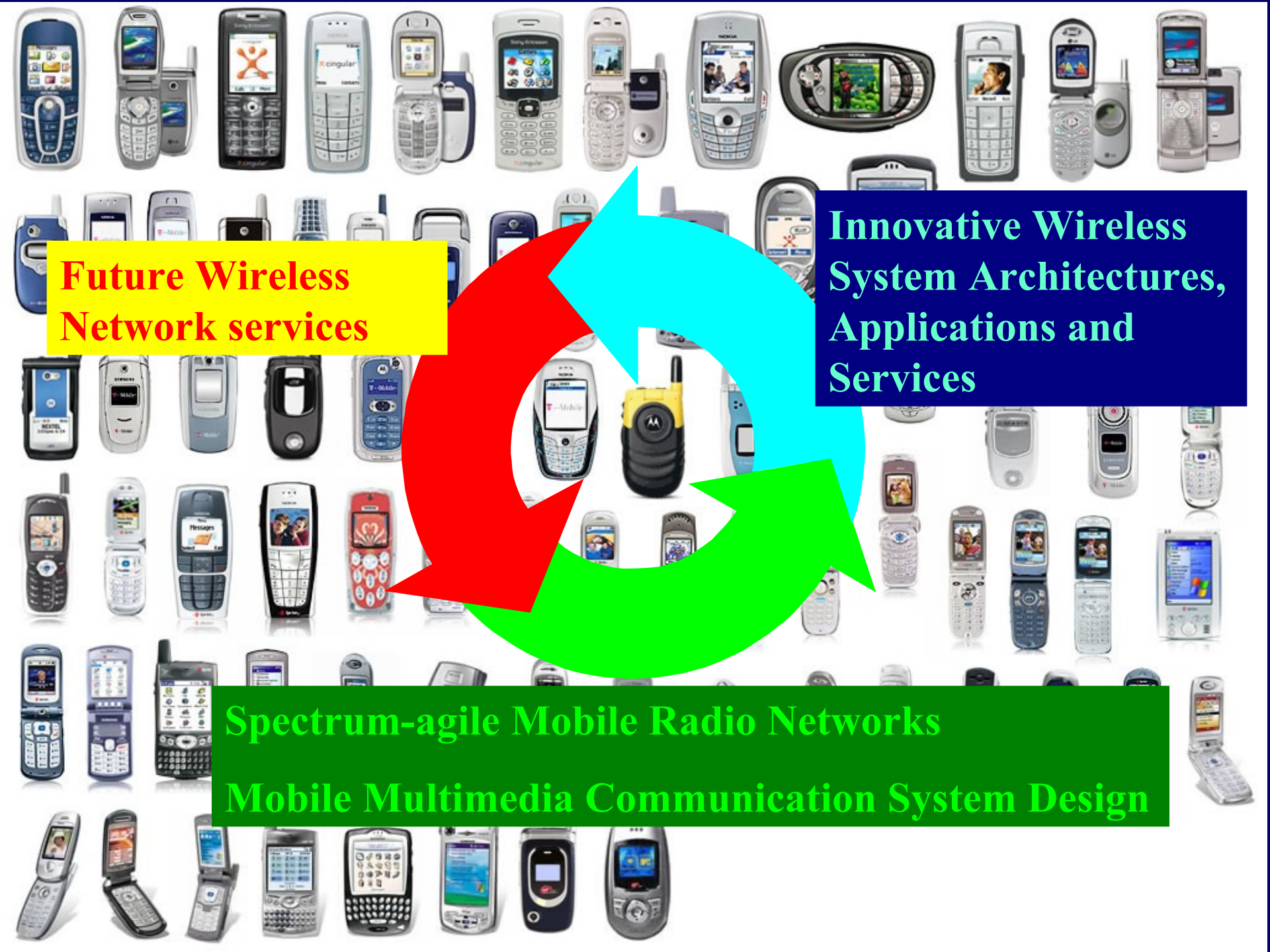


Fundamental Contributions of MobiStream
(IEEE Infocom'06)

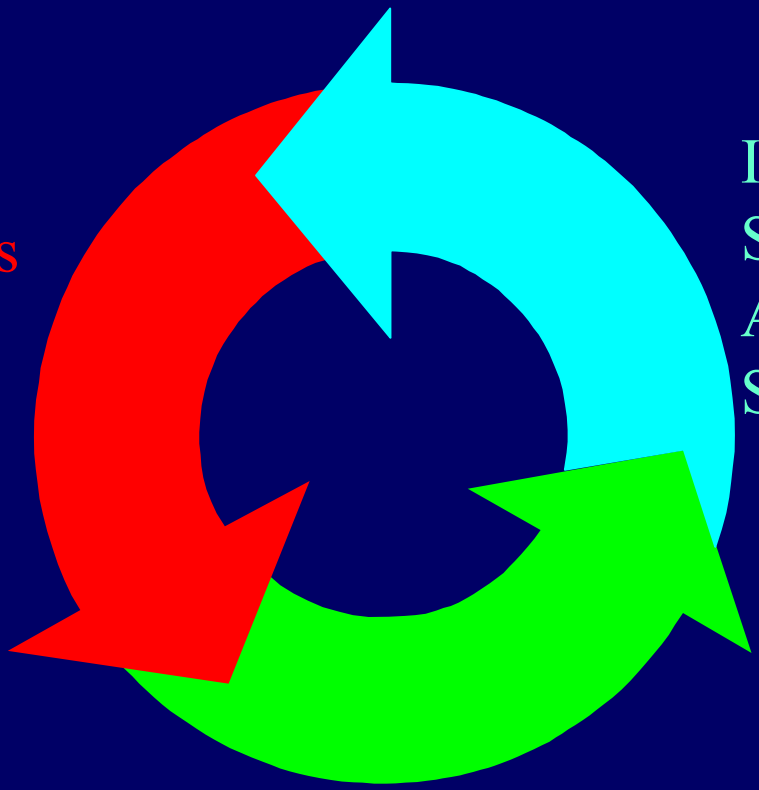
- Virtual Channels
  - Gives partial control to applications
- Perceptual Slice-structured Video
  - Improves subjective video quality
- Fine-grained error resilience
  - Gracefully overcomes bursty losses using slices
- Applications-defined link layer behaviour
  - Low-overhead Dynamic Channel Management

Other Contributions

- Flow Aggregation (IEEE Infocom'03)
- GPRSWeb (ACM Mobisys'03, 20K+ lines of code)
- Optimizing Wireless Services (ACM Mobicom'04)
- Mobile Access Router (ACM Mobisys'04)
- Exploiting diversity for Audio (IEEE Infocom'05)
- Wireless Integration and handovers (Percom'04)


Future Wireless Network services
Innovative Wireless System Architectures, Applications and Services
Spectrum-agile Mobile Radio Networks
Mobile Multimedia Communication System Design

Next Generation
Wireless Networks



Innovative Wireless
System Architectures,
Applications and
Services

Spectrum-agile Mobile Networks

Mobile Multimedia Communication System Design

Reputation system – Vito Evaluation

- 500 users (fraction of them malicious)
- Services priced randomly (1—5 units)
- Price increment/reduction factor (0.01)
- End-of-day model (the 80-20 model)
- Up to 50 services/day (max. 1000)

Impact of User Selection Policy

Services Left after 20 days

Selection Policy	Reputation	Price	Reputation/Price
Good Users	528	788	859
Malicious Users	73	789	82

Virtual Currency left after 20 days

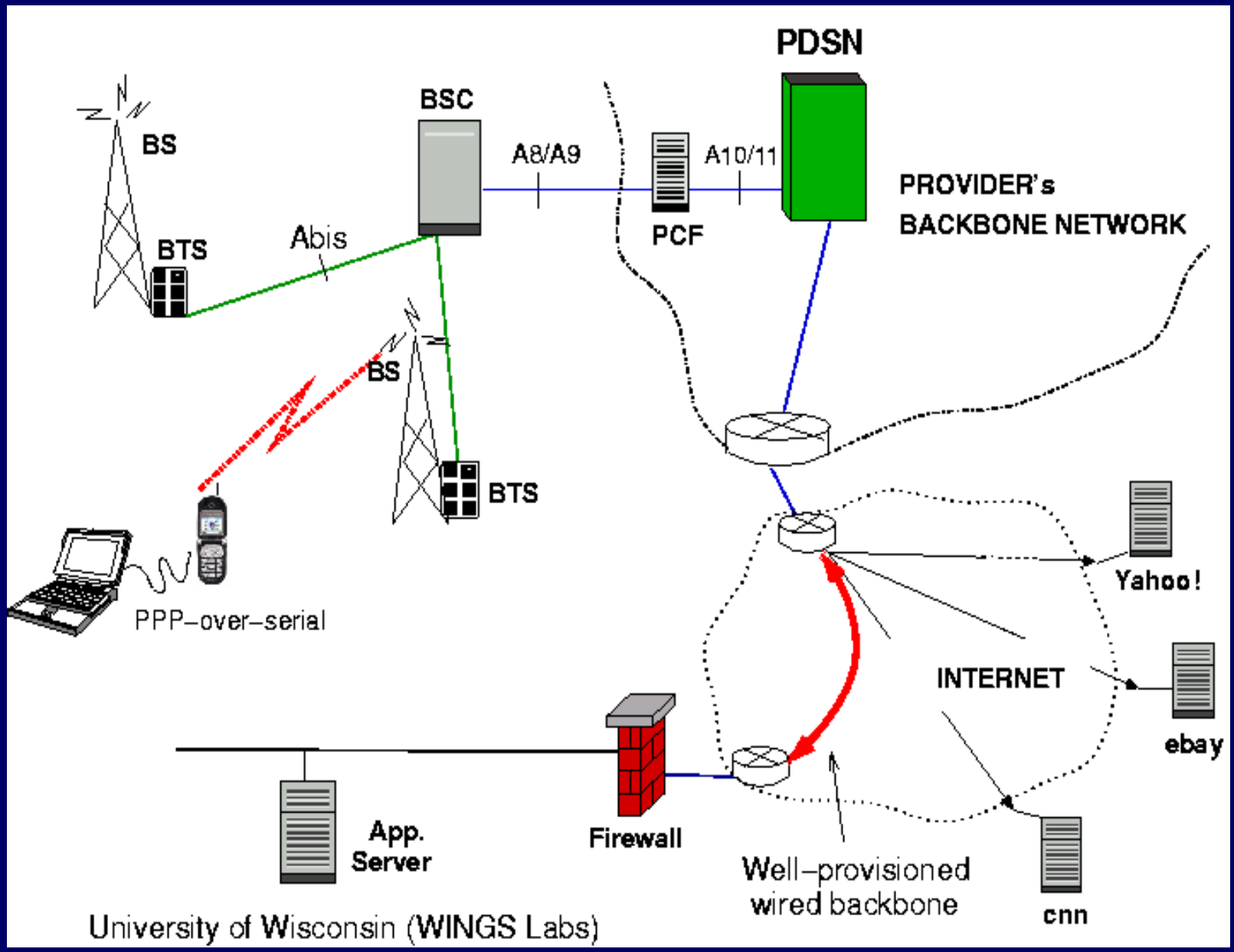
Selection Policy	Reputation	Price	Reputation/Price
Good Users	125	98	124
Malicious Users	~ 0.0	107	0.7

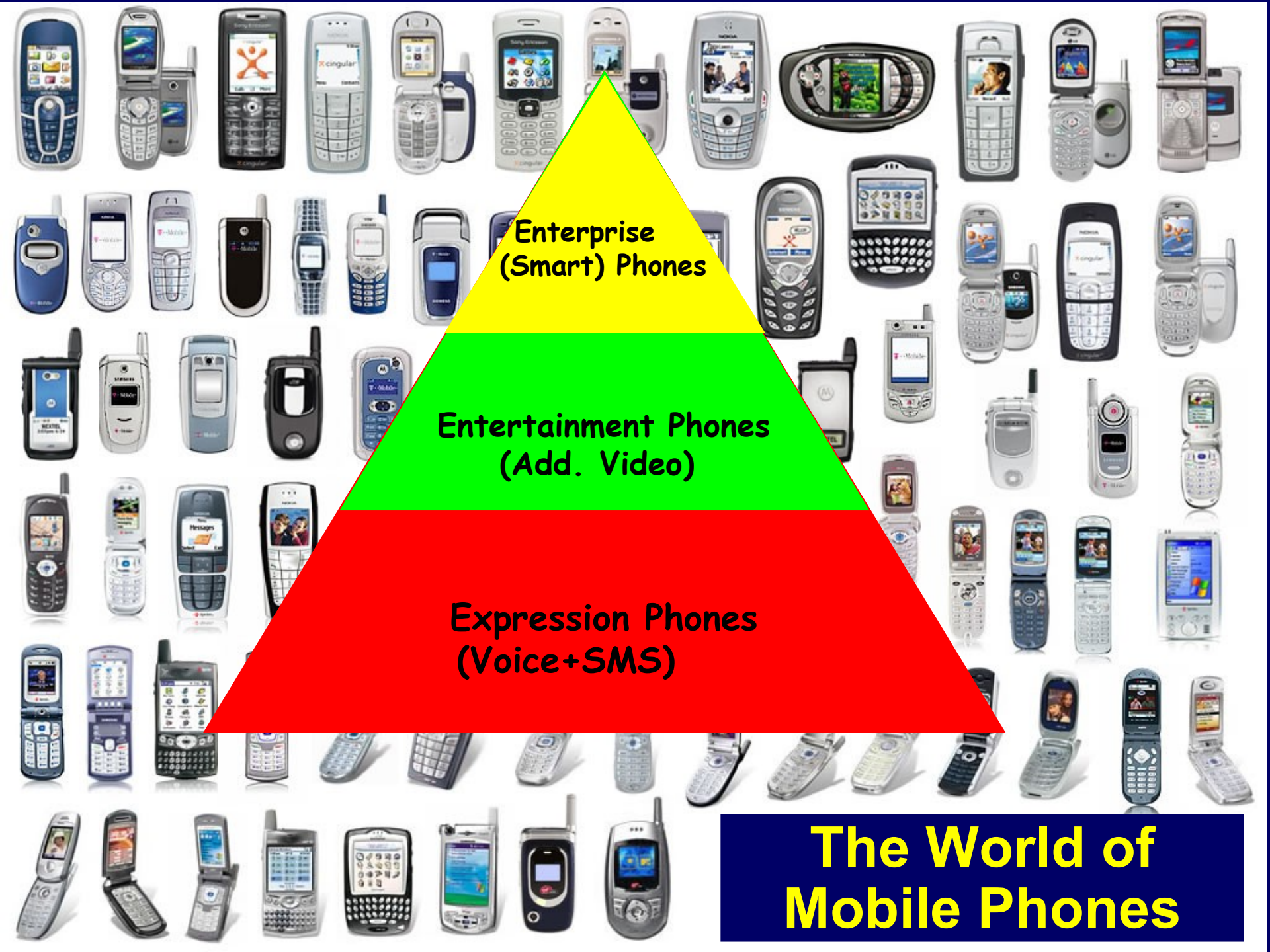
Impact of Malicious Users

Malicious %tage	Services Left (20 days)	
	Good Users	Malicious
1%	868	99
5%	870	89
10%	869	94
20%	859	82
40%	804	87

Reputation-driven policies insensitive to the fraction of malicious users

Infrastructure and Testbed




Enterprise
(Smart) Phones
Entertainment Phones
(Add. Video)
Expression Phones
(Voice+SMS)
The World of
Mobile Phones