The Case for Viral Broadband

Decentralizing broadband Internet access

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Outline

- Background and Context
- Broadband Access and Peer-to-Peer Systems
- Pricing Broadband
- Viral Broadband

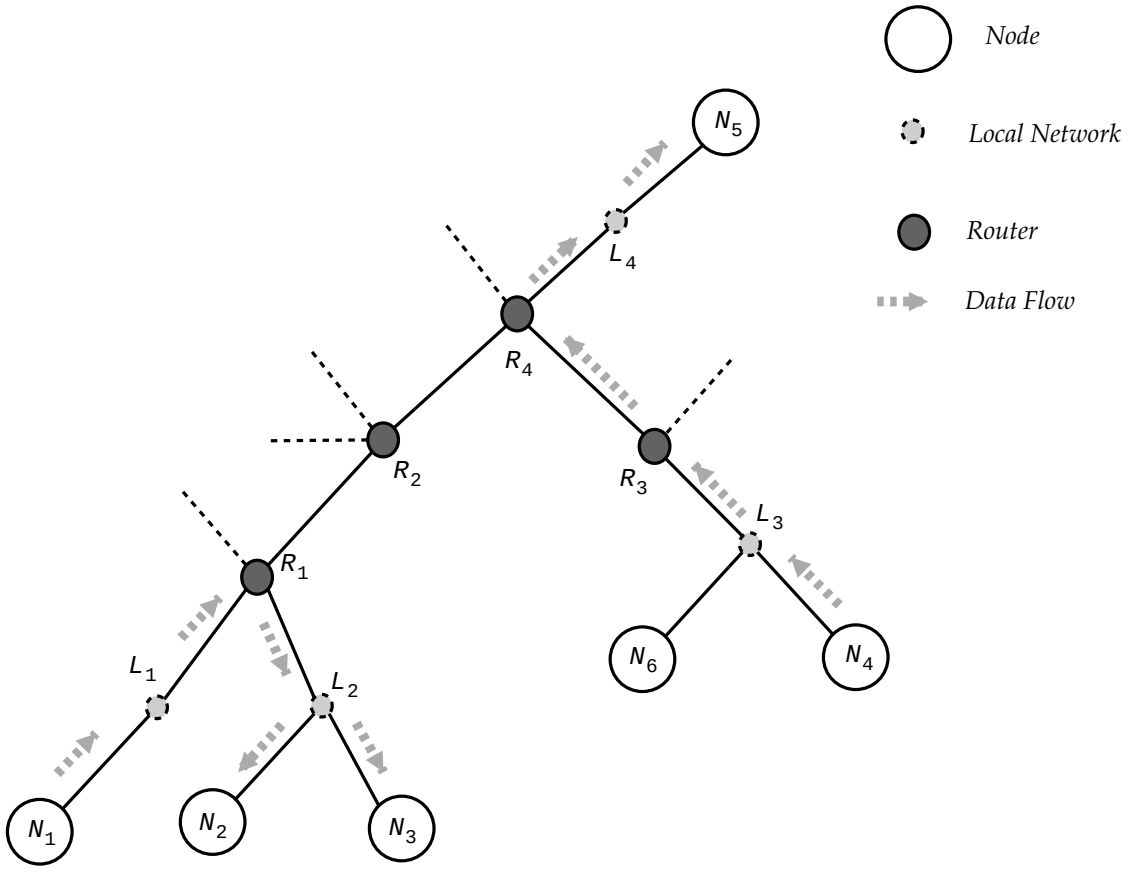
Background

Past research in Viral Communications Group: *decentralize* content distribution

- Collaborative content distribution protocols
  multicast, stream aggregation, localized distribution

- DiVA: Distributed Video Architecture
  tuner and disk space sharing

Collaborative Content Distribution



Context

Viral Broadband *decentralizes* broadband access.

- Base technology is already there (WiFi)
- Grass-roots (Roofnet etc) and city-wide (Philadelphia etc) projects, commercial offers (Nortel etc) with viral characteristics.

Impetus

- Solve the asymmetry problem.
- Enable real-time programming.
- Provide better and cheaper service for end users by leveraging wired broadband infrastructure.

Context (contd)

From decentralization to innovation: allow ideas to evolve, centralize and legitimize.

- Client-server Internet: web, online banking, etc.
- Online content distribution: file sharing $\longrightarrow$ iTunes, Raphsody.
- Peer-to-peer realtime communication: Skype
- Other industries: video, telephony, airline pricing systems, variable tolls, etc.

The State of Broadband

Broadband Network A network in which the bandwidth can be divided and shared by multiple simultaneous signals (as for voice or data or video) [Wordnet]

State of affairs

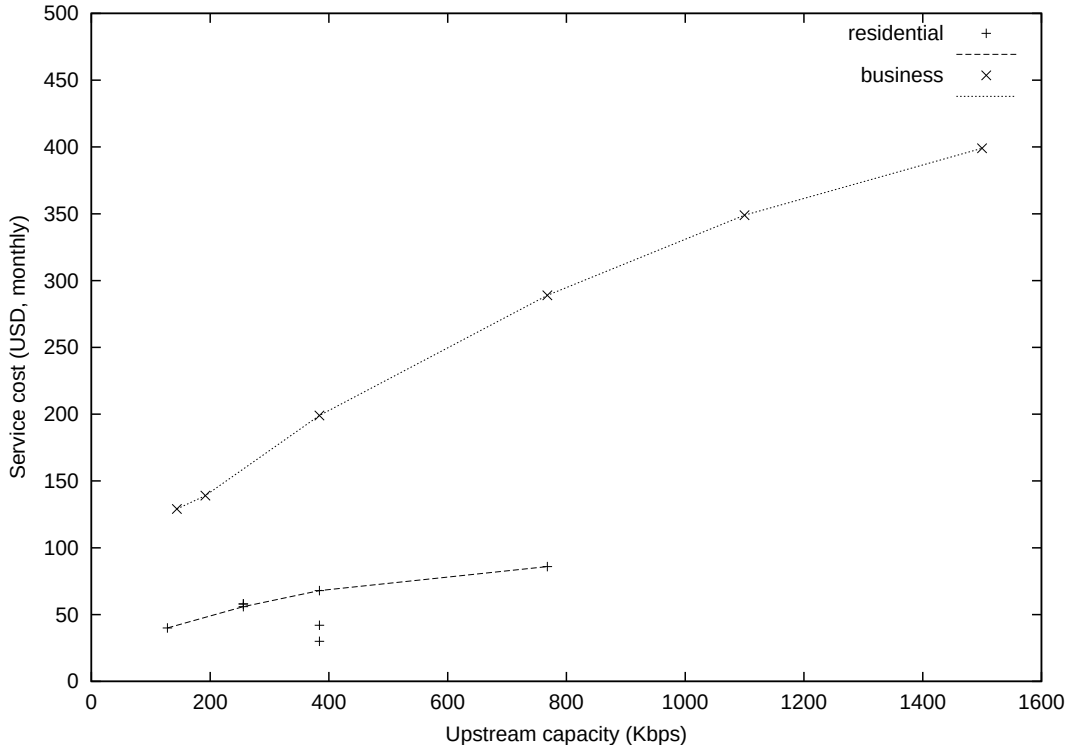
- Basic Internet service
- Asymmetric access
- Flat rate pricing

What's coming

- Multiple priorities, integrated services
- Usage-based pricing

Network Asymmetry

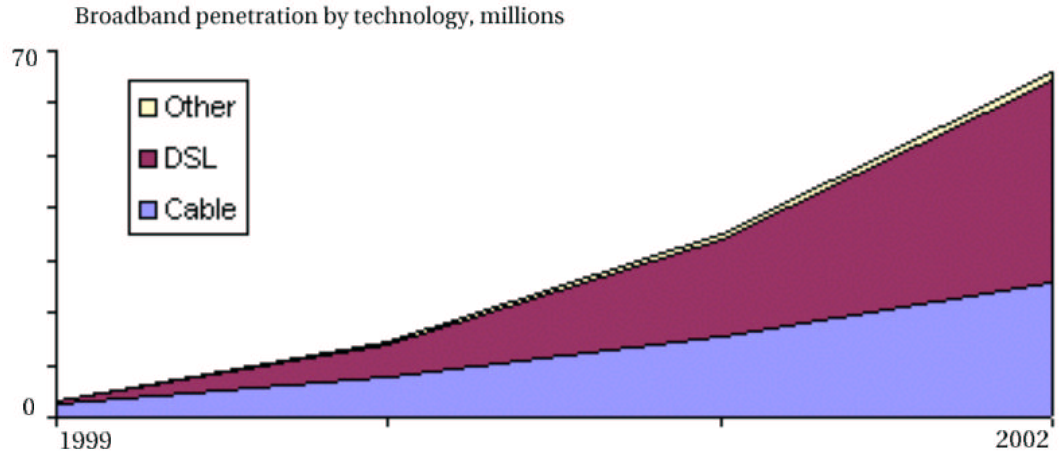
Upstream capacity 4-10 times less than downstream. Ok for client-server computing, but *not ok* for peer-to-peer applications.



Upstream capacity cost. Source: sample prices from leading ISPs

Growth of Broadband: Global

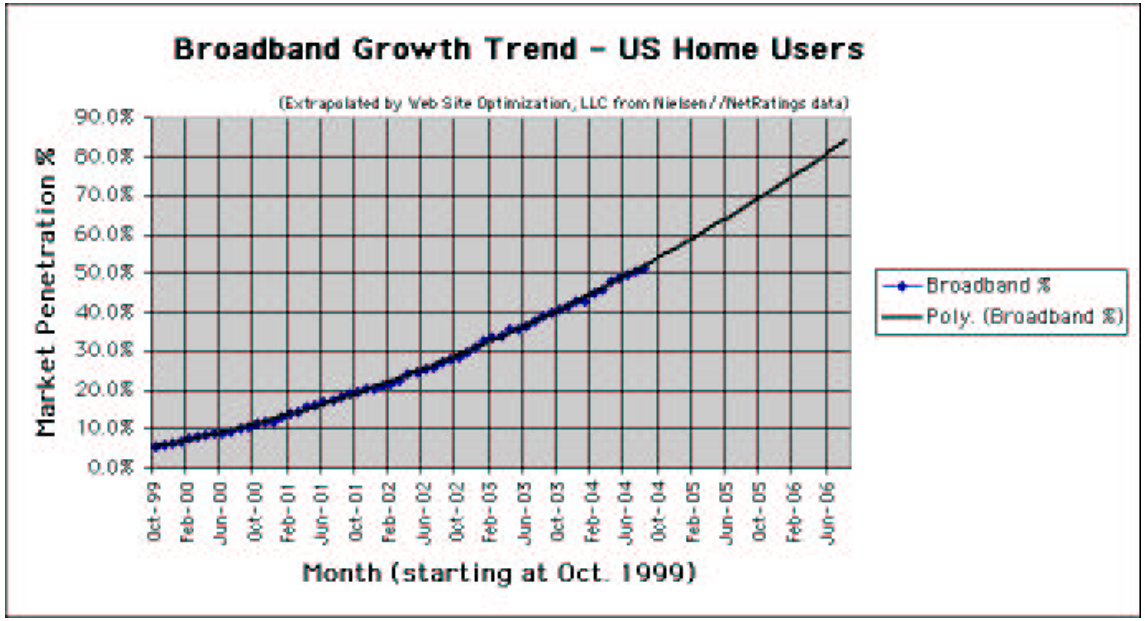
Exponential increase since 1999 to 70 million worldwide in 2002



Source: ITU

Growth of Broadband: U.S.

Market penetration over 50% in September 2004



Source: Bandwidth Report

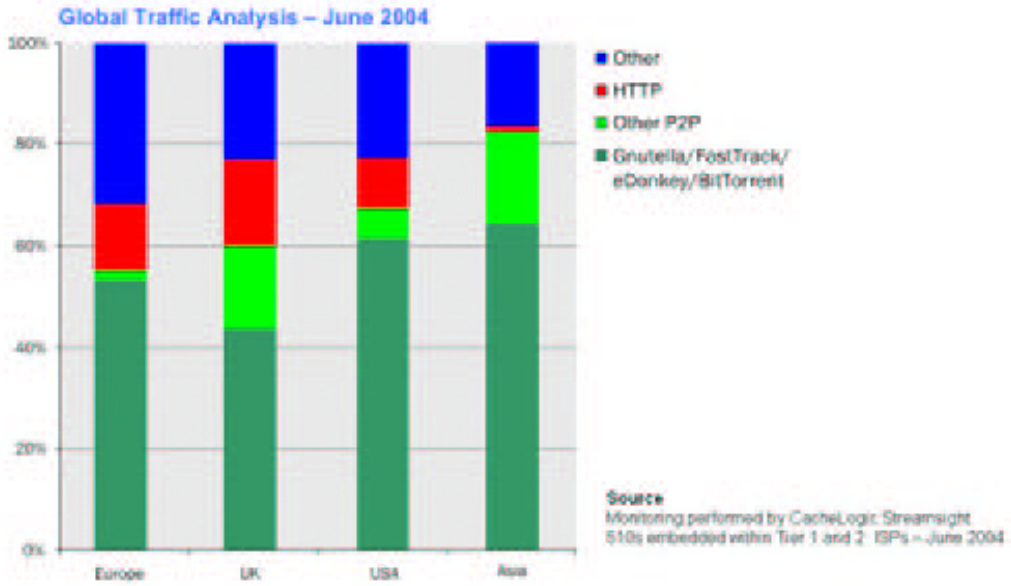
Peer-to-peer Systems and Broadband

Peer-to-peer systems is a *killer application* for broadband.

- 2001: 30 million Napster users, 40 million broadband users worldwide.
- Now: peer-to-peer is the single larger consumer of data in ISP's networks.
- Flat rate pricing: no actual cost, users encouraged to file share.
- Usage-based pricing: resource sharing is problematic.
- Network asymmetry: symmetric high bandwidth applications and real-time programming are problematic.

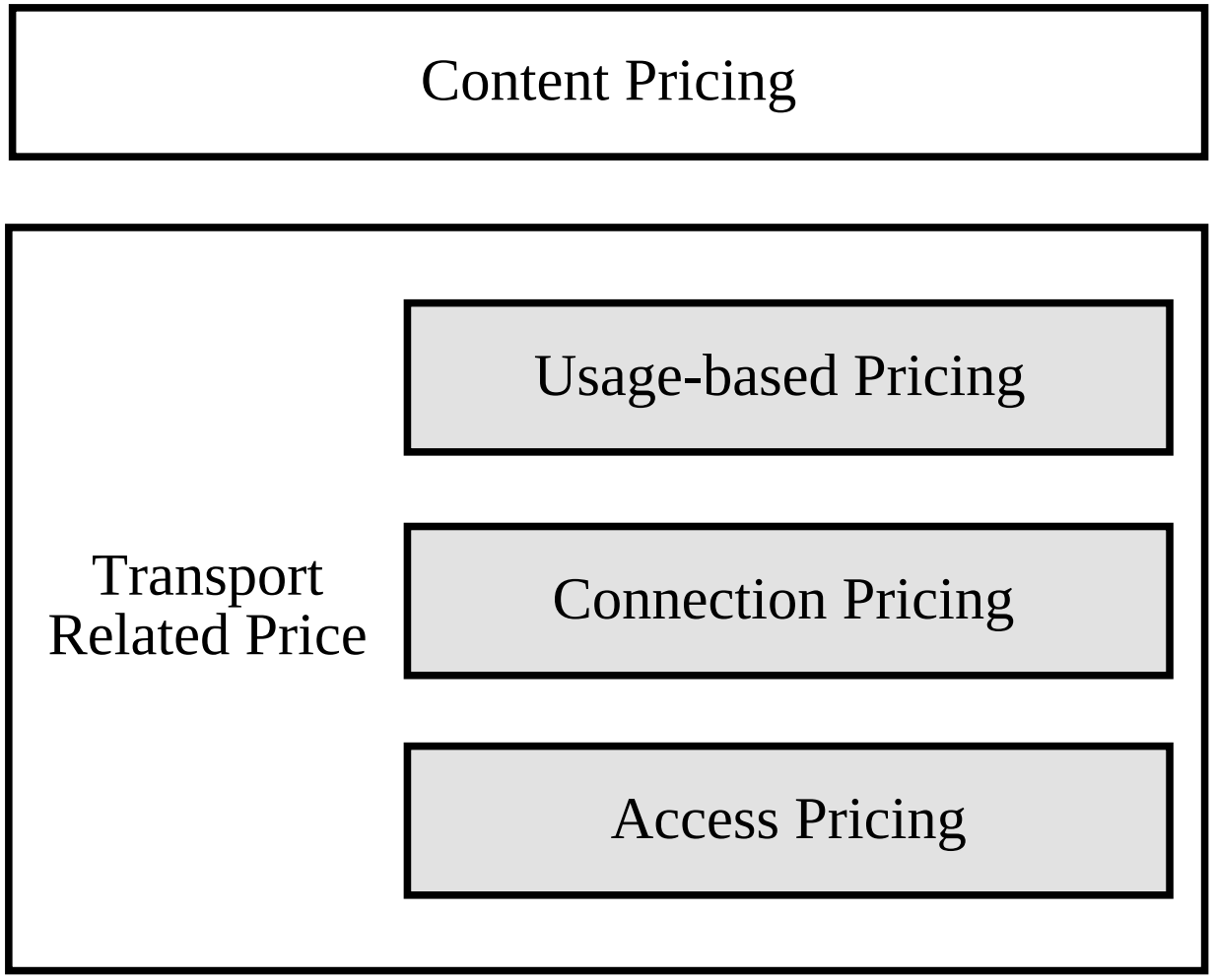
Peer-to-peer Traffic

CacheLogic analysis of tier-1 and tier-2 ISPs traffic: *Over 80% in last mile*.



Source: CacheLogic

Layered pricing model (Stiller *et al*):



Pricing Broadband: Usage Constraining Pricing

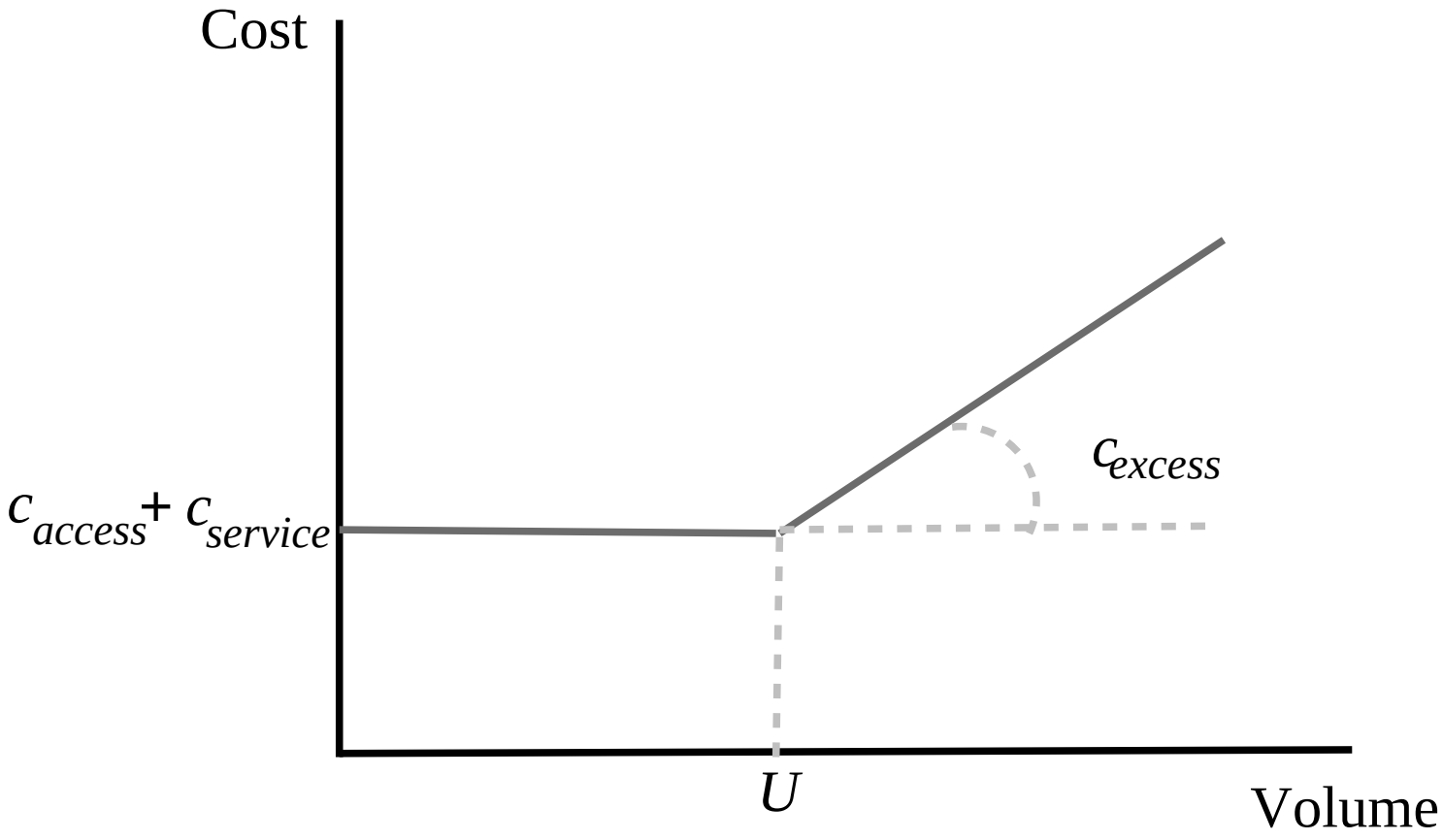
Constraining resource usage: bit counting charges with volume caps.

$$c = c_{access} + \sum_i \left(c_{service,i} + c_{excess,i} \cdot (b_i - U_i) \cdot u(b_i - U_i)\right) + c_{content}$$

c_{access}	fixed network access cost
$c_{service,i}$	ith service fixed cost
$c_{excess,i}$	ith service excess cost
b_i	ith service bit count
U_i	ith service bit cap
$u(\cdot)$	unit step function
$c_{content}$	end-to-end content cost

Pricing Broadband: Illustration

Plot of c for a single service



Viral Broadband Architecture

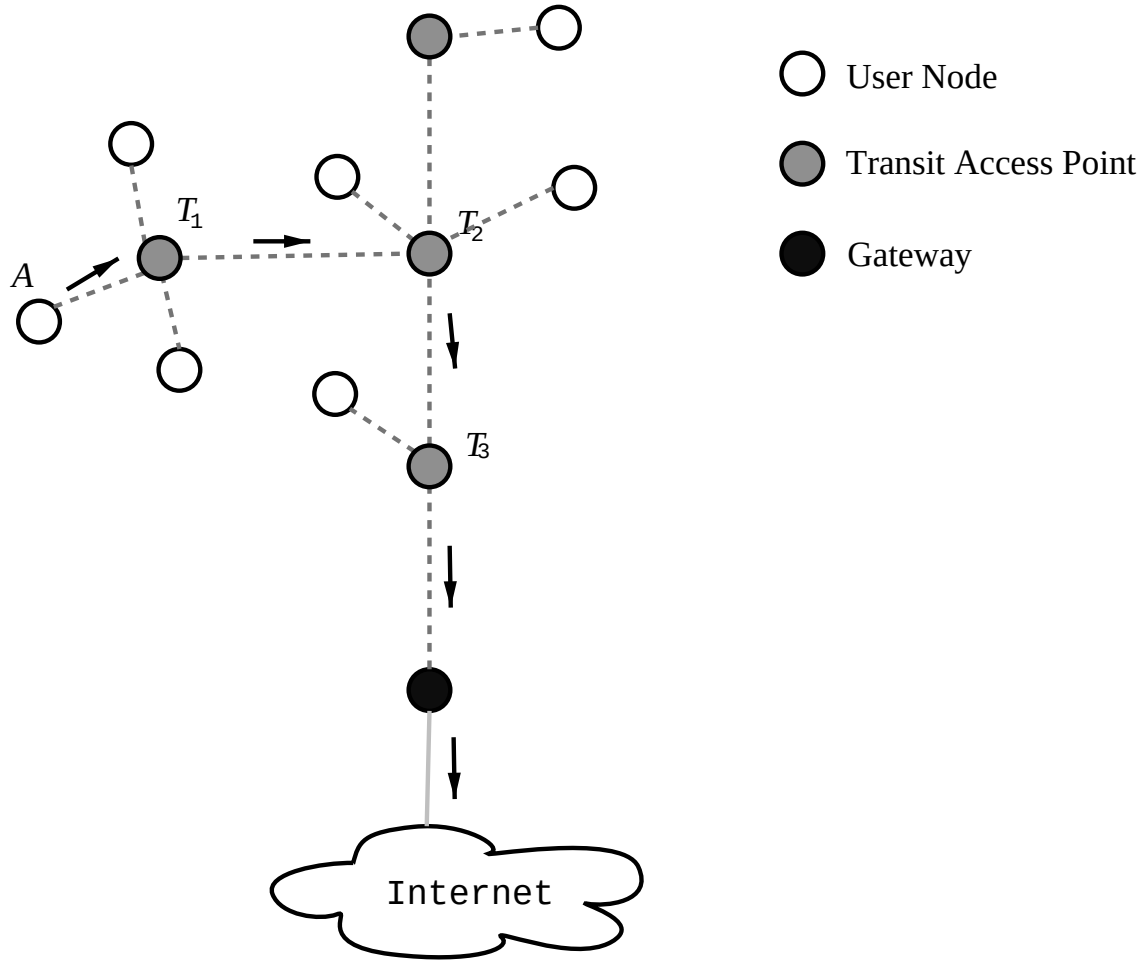
Elements of architecture

- Wireless ad-hoc network, static end user nodes provide infrastructure. Extant architecture: wireless mesh networks.
- A subset of end users provide Internet access via direct ISP connection.
- Peer-to-peer interactions.
- Turn WiFi inside-out.

Modest extrinsic requirements

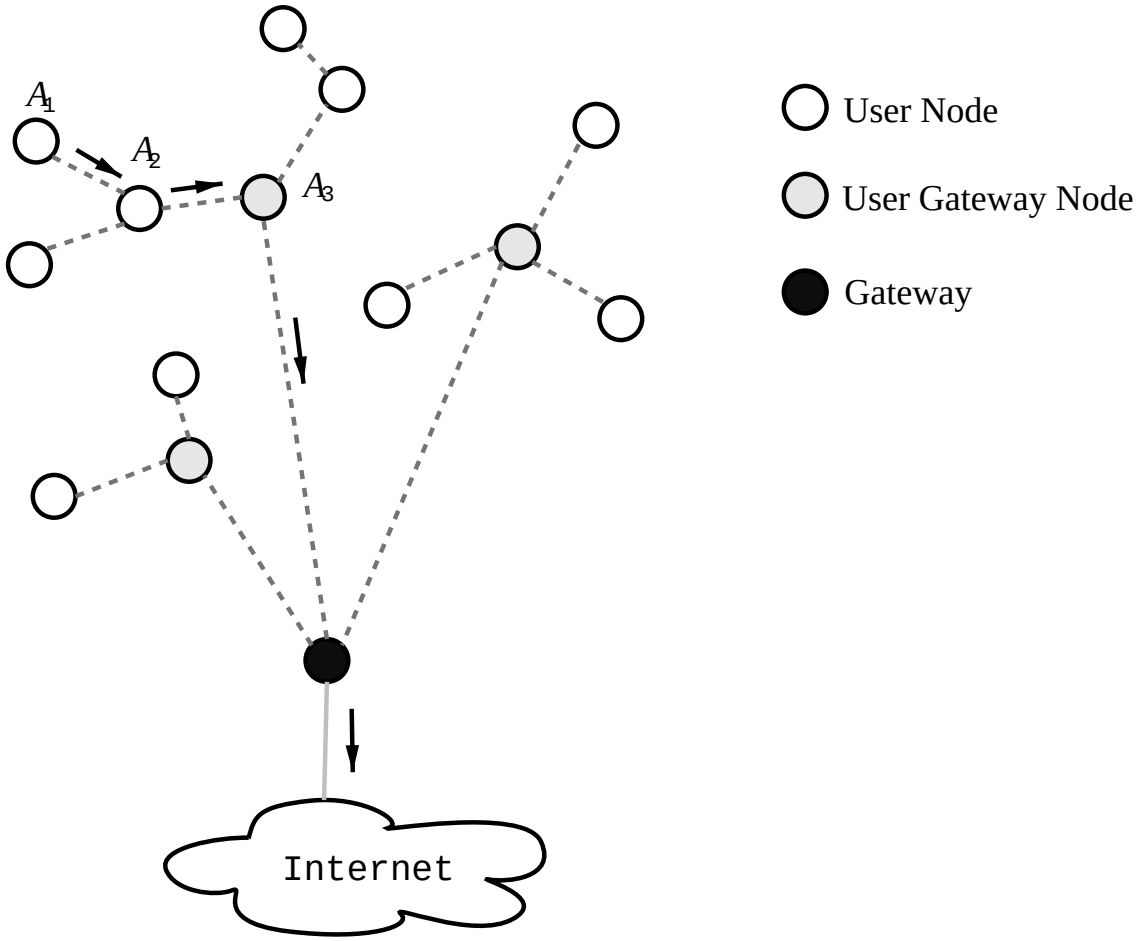
- Base technology already there: WiFi.
- Reasonable ISPs: open network access.
- Reasonable regulation: open spectrum.

Wireless Mesh Networks: ISP-centric



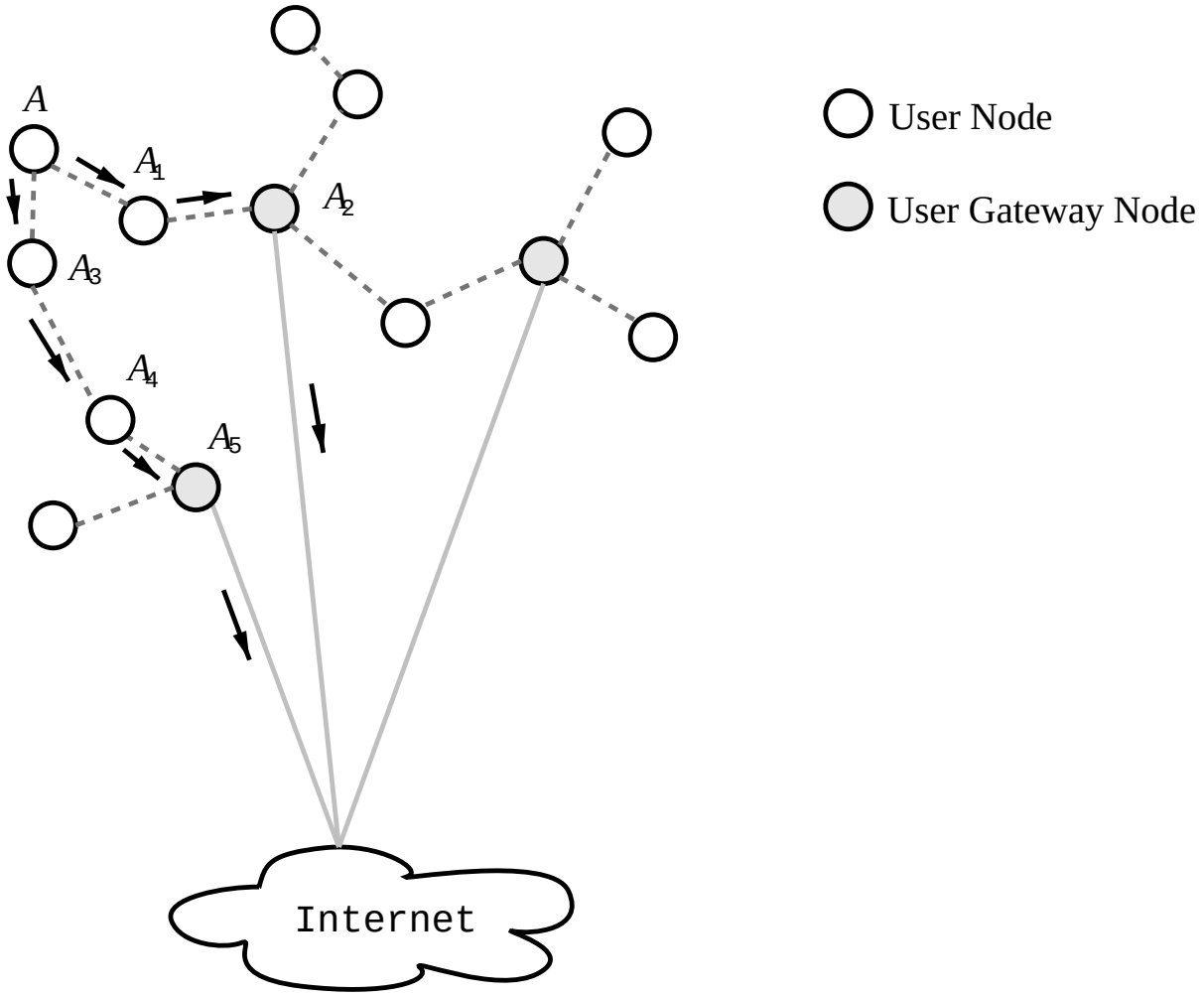
TAP-based mesh (Nortel etc)

Wireless Mesh Networks: Community-based

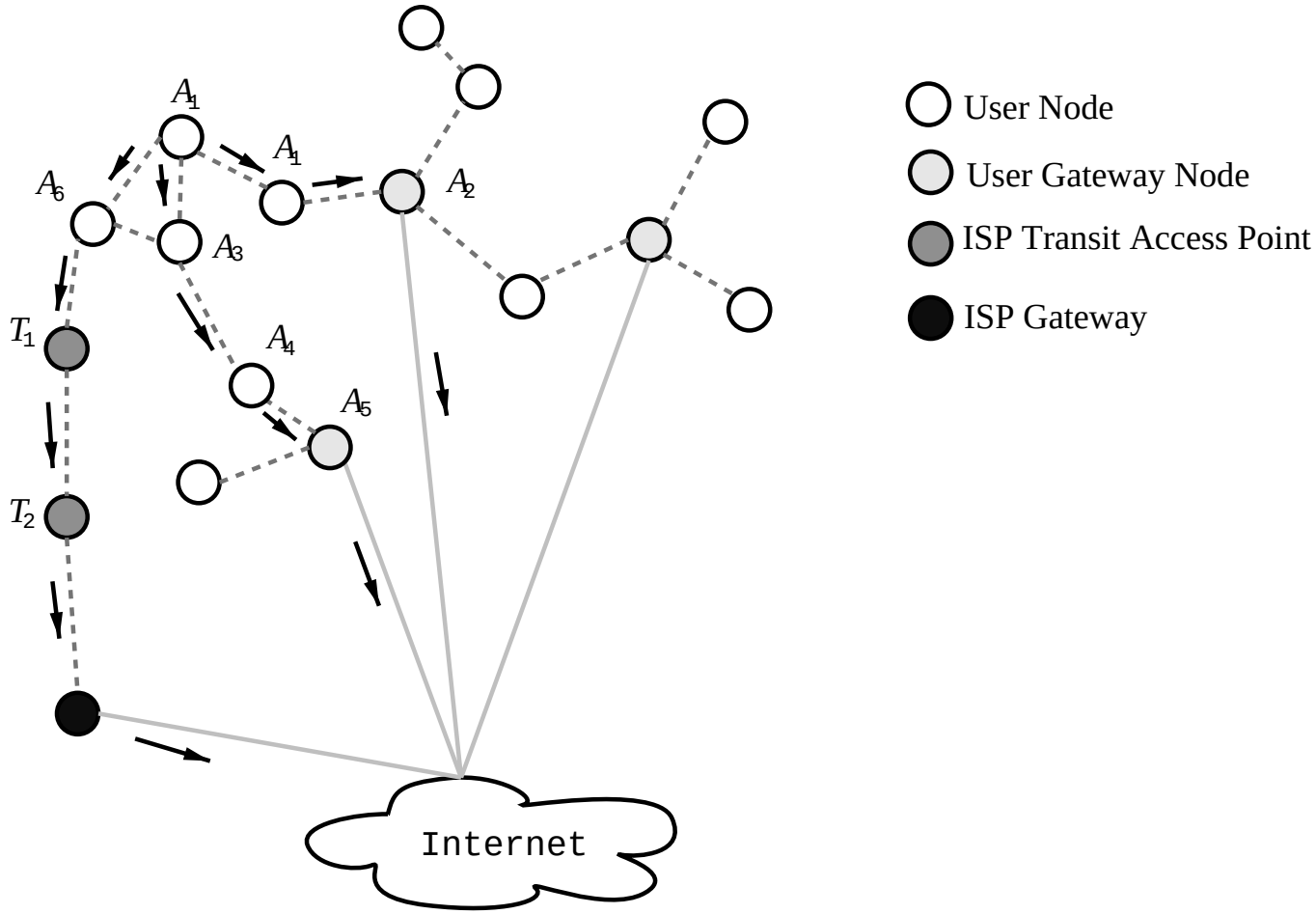


MIT Roofnet

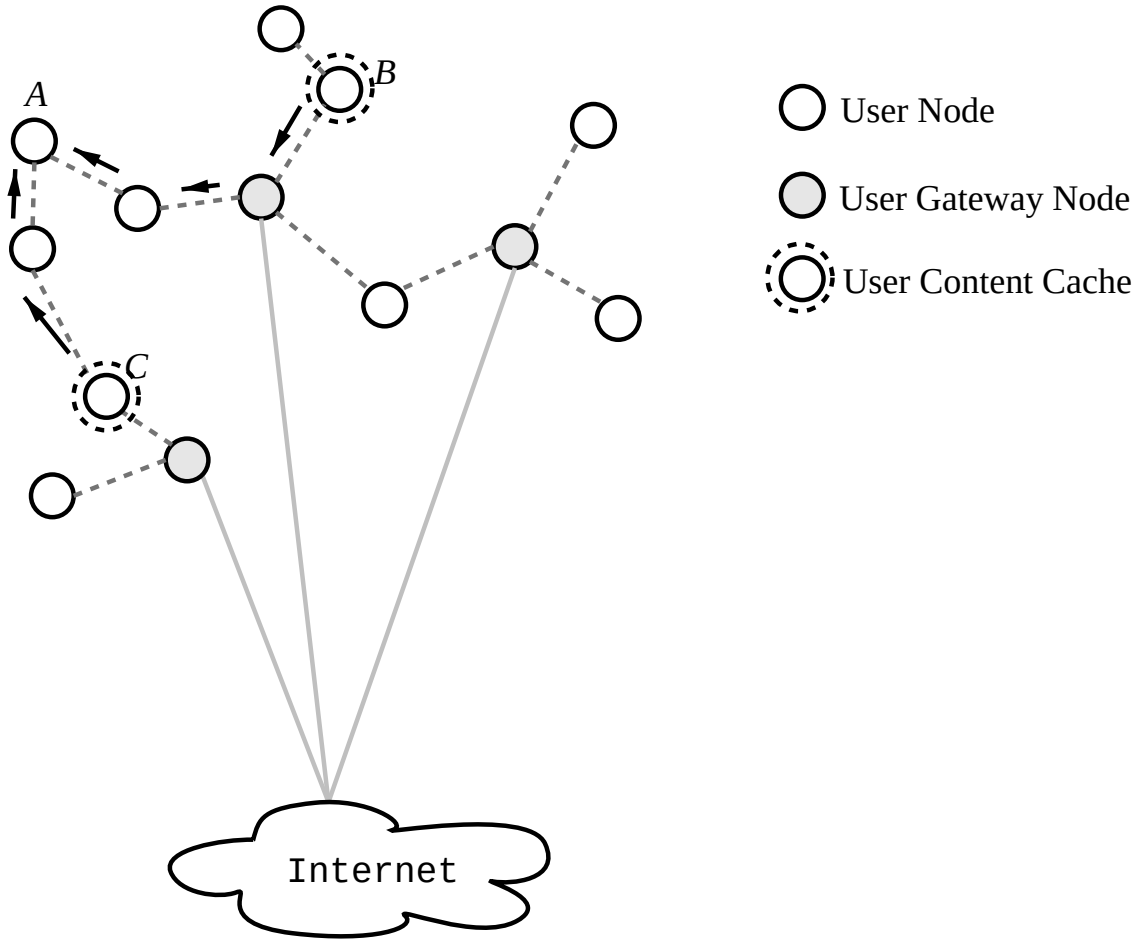
Pure Viral Broadband Architecture



Mixed Viral Broadband Architecture



Parasitic Peer-to-peer Content Distribution



Observations

- Higher capacity for users by aggregation.
- "Symmetric", peer-to-peer access.
- *Some users incur actual cost*.

Compensation by cost distribution among users according to *fair share* of resources!

Economics of Viral Broadband (contd)

Amortized access cost

$$c^*_{access} = \frac{\sum_{A_i \in A} c_{access,i}}{n}$$

Per-user viral network overhead

$$\Delta c = c_{excess} \cdot ((b_V + b - U) \cdot u(b_V + b - U) - (b - U) \cdot u(b - U))$$

User share

$$\Delta c^*_i = \frac{b_i \cdot \sum_{A_j \in A} \Delta c_j}{B}$$

n	number of users
A	subset of users with direct access
b_V	viral network excess bit count
b_i	ith user excess bit count
B	global viral network excess bit count

Benefits

- End users: symmetric access, better service, better prices.
- Base technology providers: economies of scale.
- Service providers: accounting, cost distribution.
- Content providers: efficient peer-to-peer content distribution.
- Entrepreneurs: innovation at the edge, application opportunities.

Challenges

- Fair share cost distribution: accounting, payments, efficient implementation.
- Routing: multi-gateway.
- Transport: multi-path.
- Multicast.

More Information and Progress

Viral Broadband Project

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http://web.media.mit.edu/~vyzo/vbb