Pricing – part 2
S-38.041 Networking Business

Service life cycle phases

Impact on pricing

- Introduction: early adopters, skimming vs. aggressive growth
- Growth: increasing demand, little competition, high margins
- Maturity: differentiation pressure, tough competition, low margins
- Decline: cost cutting, harvesting niche segments, high margins
Backbone services
Impact of IP

Growth of IP traffic involves evolution
- from inelastic to elastic applications (e.g. video, audio and voice coding)
- from guaranteed to best-effort services
- from deterministic to statistical multiplexing (ref. effective bandwidth)
- from bottleneck control to over-dimensioning
- from layer 2 VPN to layer 3 IP VPN

Key issue: demand vs. supply of backbone capacity?

Backbone services
Wholesale of capacity between pre-defined similar end-points

- Customers are other operators or individual firms
- Portfolio of services
  - point-to-point vs. multipoint
  - basic (dark fiber) vs. value-added (managed IP router service)
  - voice vs. data vs. video
- ATM being gradually replaced by Ethernet and MPLS
- Pricing based on Service Level Agreements (SLA) and traffic parameters (peak rate, mean rate, data loss probability, max delay, mean delay, etc)
Backbone services
Service Level Agreement (SLA)

- **Service level agreement**: a documented result of a negotiation between a customer and a provider of a service that specifies the levels of availability, performance, operation and other attributes of the service

- **Static SLA management**: SLA contract is made between two human parties and its terms cannot be changed without human intervention

- **Dynamic SLA management**: SLAs are negotiated and contracted automatically using some signaling procedures

- **SLA trading**: dynamic SLA management where information on service provisioning, routing, and pricing are exchanged between providers

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Backbone services
SLA evolution scenario

1. Static SLA management in telecom networks and dedicated data networks
2. Static SLA management in IP-based best effort networks
3. Static SLA management in IP differenc (DS) networks ?
4. Dynamic SLA management in IP DS networks ?

DS has the following SLA characteristics
- Large *traffic aggregates* (as opposed to ATM SVC)
- Typical traffic aggregates are VoIP, WWW, specific routes
- Aggregates appear as *Traffic Conditioning Agreements* (TCA)
- Traffic flows through DS domains (*via ingress/egress nodes*)
- Standardized *Per-Hop-Behaviors* (PHB) for c2e pricing?
  - *Expedited Forwarding* (EF)
  - *Assured Forwarding* (AF)
### Backbone services

#### SLA traders

**Legend**
- SLA trader
- Static SLA
- Dynamic SLA

- Dynamic SLAs between peer ISPs
- Static SLAs for end-users

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### Summary of SLA trading

- SLA trading has not been tested in real deployments
- SLA trading suits best for large networks and ISPs
- Transition from static to dynamic SLA trading is a major management challenge
- Based on simulation results, SLA trading can improve network utilization by up to 40% compared to a traditional, shortest-path routed inter-domain network
- The residual bandwidth pricing strategy is a suitable candidate for SLA trading since it ensures that prices increase with SLA or link load
Internet access services

Congestion control

- The end-to-end bottleneck may occur at different points
  - In dedicated access:
    - Increase the dedicated per subscriber access speed (e.g. ADSL)
    - Push bandwidth sharing closer to subscribers (e.g. HomePNA)
  - In shared access/backbone/server: apply congestion control

- The level of congestion needs to be optimized
  - Too much congestion ⇒ negative network externality
  - Too little congestion ⇒ waste of network capacity

- Options for congestion control
  - Over-dimensioning (wasting of network capacity)
  - Call admission control, e.g. RSVP blocking (latest customers suffer)
  - Automatic flow control, e.g. TCP (all customers suffer)
  - Human fairness control, e.g. HomePNA (local group discipline)
  - Congestion pricing (maximal social surplus?)

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Internet access services

Congestion pricing - theory

- Congestion price is two-part: normal + externality, \( p + p_E \)
  - Social surplus maximization
    \[ \max \sum u_i(x_i,y)-c(k), \text{ where } y=\sum x_i/k, \text{ total fixed capacity} \]
    \[ \Rightarrow p_E=-(1/k)\sum du/\sum x_i, \text{ where } \sum x_i=\text{socially optimal demand} \]
  - Individual maximization of surplus for consumer \( i \)
    \[ (2) \max[u_i(x_i,y)-p_Ex_i], \text{ if number of users is large} \]
  - Social and individual optimas are the same, Nash equilibrium!
  - Congestion price converges to optimal price via tatonnement:
    network determines \( p_E \) using step (1) and publishes it, then each
    consumer \( i \) solves step (2) to find \( x_i \), and so on
  - \( u_i \) are unknown ⇒ network must vary \( p_E \) until finding equilibrium
  - \( y \) is unknown to consumers ⇒ consumers estimate it via congestion
  - Congestion pricing suits for expensive bottlenecks like radio
  - Congestion pricing facilitates automatic optimal capacity
    planning via the customer feedback loop
Internet access services
Congestion pricing - practice

- Time-of-day pricing (e.g. fixed-price tickets in Internet Café)
- Pricing per application & traffic type
  - Types pre-defined using diffserv, e.g. www, VoIP, etc
  - Automatic traffic classification and resource re-allocation
- Pricing per user’s willingness-to-pay
  - Price-driven separation of service classes (e.g. Paris Metro Pricing)
  - Priority service classes based on relative quality (e.g. via diffserv)

Note that flat-rate pricing well reflects the operator’s large share of fixed cost, but cannot efficiently tackle the problem of temporary congestion!

Content services
Private vs. public goods

<table>
<thead>
<tr>
<th>Private good (e.g. candy bar)</th>
<th>Public good (e.g. radio broadcast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• You consume one, there is one less for others - depletetable</td>
<td>• Nondepletable – when used by one, the same amount is available to others.</td>
</tr>
<tr>
<td>• If consumed – no one else can - excludable</td>
<td>• Nonexcludable – Use by one does not exclude others from using the good.</td>
</tr>
<tr>
<td>• Marginal cost &gt; 0</td>
<td>• Marginal cost ≈ 0</td>
</tr>
<tr>
<td>• Price = marginal cost. Achieved on ideal market when supply = demand</td>
<td>• Price ≈ 0 → fixed cost is not recovered → taxation, non-usage based fees</td>
</tr>
</tbody>
</table>
Content services
Evolution examples

- **Best-effort IP service**: Initially public good → Flat monthly fee → Congestion → Private good externality.
- **Telephone call**: In PSTN and over radio interface = private good (“candy bar”) → price/unit.
- **Value-added IP service, e.g. VoIP**: Initially usage fee. CPU and memory getting cheaper (Moore’s law) → Marginal cost of new customer = 0 → Flat-rate.
- **Digital Content**: Marginal cost = 0 → Copyright and IPR control enable both private and public goods. Copyright violations, e.g. peer-to-peer traffic → development of digital rights management (DRM) or bundling with other private goods!

Service bundling
Vertical vs. horizontal bundling in GSM

- **Vertical bundling**
  - Bundling of access with content
  - For instance weather report over SMS
- **Horizontal bundling**
  - Bundling of access services (e.g. multiple radios, circuit vs. packet-switched, voice vs. data)
  - Bundling of vertically bundled services (e.g. weather report over SMS vs. WAP)
- **Bundling enables**
  - Cross-subsidies and service differentiation
  - Value-based pricing, i.e. flexible testing of subscriber’s willingness-to-pay
Service bundling
Roll-out of new services

- Cross-subsidies enable early roll-out of still non-profitable services
- Operator can also take risk of new handsets via handset subsidies

Case: DoCoMo i-mode pricing

Unofficial content providers (53 000)
- Content-based fee (possibly free)
- 70% free content
- Premium content: 0.39-2.34e/service/month

Official content providers (3000)
- Fixed fee
- 2.34e/month
- Premium content: 0.0023e/packet (128B) = 18e/MB
- 9% of content fee

End-user

1. Accounts for 87% of the i-mode ARPU
2. Accounts for less than 1% of the I-mode ARPU

Source: Sandro Grech, 2003 (prices 2002)
Pricing of telecom equipment

- Traditionally pricing is based on hardware capacity (e.g. switching centers, routers, base stations), which hides software R&D costs → pressure to price software
- Capacity pricing is adapted per type of capacity
  - GSM MSC switching capacity (number of simultaneous calls)
  - GSM HLR storage capacity (number of subscribers)
  - GSM BTS radio transmission capacity (number of TRXs)
  - IP router capacity (bits/sec, packets/sec, number of ports, etc)
  - Server transaction capacity (SMS/sec, locations/sec, etc)
- Growing exploitation of general purpose operating systems and hardware (e.g. Unix) in network elements is likely to gradually un-bundle the pricing of software and hardware