Interconnection and Roaming

(Courcoubetis&Weber: Chapter 12)
Interconnection

Regulation

EU Relevant Markets include wholesale interconnection:

- Call origination/termination in an individual PSTN
- Transit services in the fixed PSTN
- Access and call origination in public mobile networks (often SMPs)
- Voice call termination in public mobile networks (always SMPs)

GSM call termination monopoly implies that

- regulator adjusts the termination prices according to operator size

Mobile Virtual Network Operators (MVNO) can survive if

- they get access capacity from MNOs (SMP decisions if necessary)
- their call termination prices do not need to be cost-oriented

Removing interconnection regulation would rapidly consolidate a mobile market
Business interfaces in Internet

- Business interfaces are technically managed via announcements and withdrawals of destination routes (e.g. Border Gateway Protocol).
- Three types of agreement:
  - direct bilateral peering: non-transitive traffic exchanged without payment
  - bilateral peering through NAP (matchmaker -> bandwidth broker)
  - true transit traffic involving charging (typically per volume)
- Optimal business choice between peering and transit?
Interconnection
Charging schemes

• Calling-party’s network pays (CPNP)
  – calling operator pays to called operator for call termination (e.g. telephony)
  – terminating operator is a de-facto monopolist ⇒ high termination charges
  – lock-in creates an opportunity for disruptive technologies such as IP telephony

• Sender Keep All (SKA, Bill-and-keep)
  – appears as peering agreements in Internet
  – network effect ⇒ discouraging to big operators ⇒ cost sharing
    e.g. facility-based interconnection cost charging ⇒ equal customer prices

• Revenue sharing
  – typically new entrant pays to incumbent (e.g. content provider to operator)
  – simple but potentially anti-competitive

• Interconnect charges based on retail prices
  – retail prices sometimes used as reference for inter-operator discounts
  – sometimes enforced by regulator

Source: Courcoubetis, Weber, 2003
Interconnection
Case Finland, April 2004

• Impact of regulator’s threat (Significant Market Power identification for mobile operators) on termination prices for GSM mobile-to-mobile calls
  – Sonera Mobile 9c/min (earlier 12,78c/min)
  – Elisa Mobile 10c/min (earlier 13,12c/min)
  – Finnet/DNA 11c/min

• National ISP interconnection is handled via FICIX ry
  – Non-profit organization (membership and port fees only)
  – No transit traffic allowed
  – Bilateral agreements required but without charging settlements
Backbone services
Impact of IP

• Growth of IP traffic involves evolution
  – from inelastic to elastic applications (e.g. video streaming inelastic → elastic)
  – from guaranteed services to best-effort (the fundamental nature of IP is best-effort)
  – 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 legal 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
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 diffserv (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 e2e 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
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
Roaming
Regulation

EU Relevant Markets include wholesale roaming:
• Wholesale national market for international roaming on public mobile

EU is adding pressure on roaming prices
• retail price caps enforced in summer 2007 for GSM voice and SMS
• ultimatum to operators regarding Internet roaming!

National regulators have difficulty in guiding international roaming prices because costs come from abroad

Internet-based access-independent approaches of solving the roaming problem (e.g. Voice-over-Internet by Skype) are likely to push roaming prices down
Mobile Roaming Relationships

- Separation of service and network operations
- Wholesale\textsubscript{National} : between service operator (SO) or MVNO with the national network operator (NO)
- Wholesale\textsubscript{International} : between NOs (home and visited) which is typically international in nature.
Importance of Roaming

<table>
<thead>
<tr>
<th>World</th>
<th>Arrivals by purpose of visit (including estimations for countries with missing data)</th>
<th>International Tourist Arrivals</th>
<th>Market share</th>
<th>Growth rate</th>
<th>Average annual growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td>455.9</td>
<td>550.4</td>
<td>667.3</td>
<td>684.1</td>
</tr>
<tr>
<td>Leisure, recreation and holidays</td>
<td>28.0</td>
<td>33.1</td>
<td>37.1</td>
<td>36.0</td>
<td>62.3</td>
</tr>
<tr>
<td>Business and professional</td>
<td>57.8</td>
<td>80.1</td>
<td>130.3</td>
<td>129.4</td>
<td>12.7</td>
</tr>
<tr>
<td>VFR, health, religion, other</td>
<td>74.4</td>
<td>106.5</td>
<td>154.3</td>
<td>161.8</td>
<td>16.3</td>
</tr>
<tr>
<td>Not specified</td>
<td>39.8</td>
<td>24.8</td>
<td>30.6</td>
<td>27.0</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Source: World Tourism Organization (WTO) ©
(Data as collected by WTO September 2003)

- Traditional customers: business
- Number of private customers increasing
- International roaming market not yet matured
Roaming Financials
Revenue Forecast

<table>
<thead>
<tr>
<th>Region</th>
<th>Intra-continental Roaming ($ millions)</th>
<th>Inter-continental Roaming ($ millions)</th>
<th>Total Roaming Revenues ($ millions)</th>
<th>Total Service Revenue ($ millions)</th>
<th>Roaming as a % of Total Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>$15,973</td>
<td>$16,546</td>
<td>$465</td>
<td>$1,670</td>
<td>$16,438</td>
</tr>
<tr>
<td>North America</td>
<td>1,011</td>
<td>1,543</td>
<td>68</td>
<td>1,513</td>
<td>1,079</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>1,211</td>
<td>1,404</td>
<td>65</td>
<td>887</td>
<td>1,276</td>
</tr>
<tr>
<td>South America</td>
<td>175</td>
<td>229</td>
<td>47</td>
<td>400</td>
<td>221</td>
</tr>
<tr>
<td>Total</td>
<td>$18,370</td>
<td>$19,723</td>
<td>$644</td>
<td>$4,470</td>
<td>$19,014</td>
</tr>
</tbody>
</table>

Source: April 2002 IDC International Roaming White Paper, entitled “How Important Is International Roaming to Wireless Network Migration?”

Roaming is currently
– c. 2% of mobile operator’s traffic
– c. 10-15% of mobile operator’s revenue
Roaming Financials
Revenue and cost break-down - Generic CDMA operator

<table>
<thead>
<tr>
<th>Revenue - Outbound</th>
<th>FYE</th>
<th>Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique Subscribers</td>
<td>35,000</td>
<td>Cost of Service</td>
</tr>
<tr>
<td>Avg. # of Visits per Year</td>
<td>2</td>
<td>Inter-Operator Tariff - Outbound Roaming</td>
</tr>
<tr>
<td>Avg. # of Days per Visit</td>
<td>5</td>
<td>Network Cost per MOU - Inbound Roaming</td>
</tr>
<tr>
<td>Avg. # of Calls per Day</td>
<td>5</td>
<td>Signaling</td>
</tr>
<tr>
<td>Avg. # of Minutes per Call</td>
<td>3</td>
<td>Rental of Lease Line for Frame Relay</td>
</tr>
<tr>
<td>Avg. Price per Minute</td>
<td>$2.00</td>
<td>3rd Party Processing/Routing Service</td>
</tr>
<tr>
<td><strong>Subtotal - Outbound Revenue</strong></td>
<td>$10,500,000</td>
<td><strong>Total Signaling Cost</strong></td>
</tr>
<tr>
<td>Revenue - Inbound</td>
<td>15,000</td>
<td>Financial Settlement</td>
</tr>
<tr>
<td>Unique Subscribers</td>
<td>2</td>
<td>3rd Party Message Processing</td>
</tr>
<tr>
<td>Avg. # of Visits per Year</td>
<td>5</td>
<td>CIBER/CIBERNET License Fee</td>
</tr>
<tr>
<td>Avg. # of Days per Visit</td>
<td>5</td>
<td><strong>Total Financial Settlement Cost</strong></td>
</tr>
<tr>
<td>Avg. # of Calls per Day</td>
<td>5</td>
<td>Fraud Management</td>
</tr>
<tr>
<td>Avg. # of Minutes per Call</td>
<td>3</td>
<td>RoamX</td>
</tr>
<tr>
<td>Avg. Price per Minute</td>
<td>$1.00</td>
<td><strong>Subtotal - Cost of Service</strong></td>
</tr>
<tr>
<td><strong>Subtotal - Inbound Revenue</strong></td>
<td>$2,250,000</td>
<td>Gross Margin</td>
</tr>
<tr>
<td>Gross Int’l Roaming Revenue</td>
<td>$12,750,000</td>
<td>SG&amp;A</td>
</tr>
<tr>
<td>Less: Bad Debt</td>
<td>$6,375,000</td>
<td>EBITDA</td>
</tr>
<tr>
<td><strong>Net Int’l Roaming Revenue</strong></td>
<td>$12,112,500</td>
<td>Depreciation of Non-recurring Expenses</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>EBIT</strong></td>
</tr>
</tbody>
</table>

Note: Estimated costs for a generic CDMA operator

- Note: most revenue is from outbound traffic
- Note: margins are high
- Note: trust is a key issue (ref. 5% bad debt)

Source: International Roaming Business Overview: Qualcomm
GPRS Roaming
Technical Architecture - Bilateral

Source: Renjish Kaleelatzicathu, 2004
GPRS Roaming
Technical Architecture – Single GRX
GPRS Roaming
Technical Architecture – Multiple GRXs
GPRS Roaming

Business Interfaces between Players

- Bilateral roaming agreements between GPRS operators
- Settlement of inter-operator tariffs (IOT) via clearing houses
- Transport agreements via GPRS Roaming eXchange (GRX) operators

Source: Renjish Kaleelatzicathu, 2004
### GPRS Roaming

**Business Model Scenarios: Bilateral, Clustered, Centralized**

<table>
<thead>
<tr>
<th>Triggers\Models</th>
<th>Bilateral</th>
<th>Clustered</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of contracts</strong></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Complexity of one contract</strong></td>
<td>High</td>
<td>High</td>
<td>Low ?</td>
</tr>
<tr>
<td><strong>Management structure</strong></td>
<td>Distributed</td>
<td>Centralized</td>
<td>Centralized</td>
</tr>
<tr>
<td><strong>Vertical bundling</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No ?</td>
</tr>
<tr>
<td><strong>Control of standards spec</strong></td>
<td>GSM MoU</td>
<td>Operator</td>
<td>Non-commercial</td>
</tr>
<tr>
<td><strong>Competition in roaming</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Price regulations</strong></td>
<td>No</td>
<td>No</td>
<td>Yes ?</td>
</tr>
<tr>
<td><strong>Cost per operator</strong></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Profit opportunity</strong></td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

- Bilateral model has dominated so far
- Clustered model develops together with global operators
- Centralized model may emerge from regulatory needs
WLAN Roaming
System Architecture using RADIUS

- Authentication based on RADIUS protocol (DIAMETER)
- WLAN charging and settlement handled by Clearing House
WLAN Roaming
Public Hotspots Globally per Location

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airports</td>
<td>75</td>
<td>200</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>650</td>
<td>700</td>
</tr>
<tr>
<td>Hotels</td>
<td>520</td>
<td>2,500</td>
<td>9,000</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
<td>45,000</td>
</tr>
<tr>
<td>Retail outlets</td>
<td>320</td>
<td>12,000</td>
<td>44,000</td>
<td>60,000</td>
<td>75,000</td>
<td>85,000</td>
<td>90,000</td>
</tr>
<tr>
<td>Enterprise Guesting Areas</td>
<td>84</td>
<td>600</td>
<td>1,000</td>
<td>4,000</td>
<td>5,000</td>
<td>6,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Transportation (trains, planes)</td>
<td>100</td>
<td>600</td>
<td>2,000</td>
<td>14,000</td>
<td>23,000</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td>Community Hotspots</td>
<td>1</td>
<td>300</td>
<td>3,000</td>
<td>5,000</td>
<td>8,000</td>
<td>9,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Others</td>
<td>300</td>
<td>1,000</td>
<td>1,500</td>
<td>2,400</td>
<td>3,350</td>
<td>4,300</td>
<td></td>
</tr>
<tr>
<td><strong>Total number of hotspots</strong></td>
<td><strong>1,000</strong></td>
<td><strong>16,000</strong></td>
<td><strong>59,000</strong></td>
<td><strong>93,000</strong></td>
<td><strong>135,000</strong></td>
<td><strong>167,000</strong></td>
<td><strong>190,000</strong></td>
</tr>
</tbody>
</table>

Source: Gartner

Note: status per 01-Jul-2003 estimated at 10,000 of which 12,000 in South Korea
### WLAN Roaming

**Public Hotspots per Region**

<table>
<thead>
<tr>
<th># of Hot Spots</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>50</td>
<td>1,000</td>
<td>5,000</td>
<td>9,400</td>
<td>17,700</td>
<td>24,000</td>
<td>28,200</td>
</tr>
<tr>
<td>Americas</td>
<td>750</td>
<td>4,000</td>
<td>18,000</td>
<td>30,000</td>
<td>45,000</td>
<td>55,000</td>
<td>62,000</td>
</tr>
<tr>
<td>Far-East</td>
<td>100</td>
<td>10,500</td>
<td>25,000</td>
<td>51,500</td>
<td>69,000</td>
<td>83,000</td>
<td>93,000</td>
</tr>
<tr>
<td>ROW</td>
<td>500</td>
<td>1,000</td>
<td>2,100</td>
<td>3,300</td>
<td>5,000</td>
<td>6,800</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>900</strong></td>
<td><strong>16,000</strong></td>
<td><strong>49,000</strong></td>
<td><strong>93,000</strong></td>
<td><strong>135,000</strong></td>
<td><strong>167,000</strong></td>
<td><strong>190,000</strong></td>
</tr>
</tbody>
</table>

Growth Total: 1678% 206% 90% 45% 24% 14%
Growth Europe: 1900% 400% 88% 88% 36% 18%

Source: IDC + various other sources

Note: Europe is catching up this year
WLAN vs. GPRS Roaming

- GPRS roaming being deployed based on home-network routing (cmp. GSM)
- WLAN roaming being deployed based on visited network routing (direct local access to Internet) ⇒ strong trust required between operators
- Roll-out of WLAN in handsets is likely to increase the use of SIM/HLR authentication for roaming
- GRX enables end-to-end quality of service (QoS) control
  - MMS uses GRX for both interconnect and roaming traffic
  - Voice-over-IP on public WLAN could use GRX for QoS
Roaming Agreements
Case: Sonera in April 2004

- International roaming coverage
  - GSM in c. 100 countries (c. 220 operators)
  - GPRS in c. 50 countries (c. 90 operators)
  - WLAN (GSM Association IR.61) in 16 countries (3500 hotspots)
- Sonera GRX service connects e.g. all Finnish mobile operators to each others and to foreign networks
- Sonera builds own public WLAN coverage in Finland
  ⇒ no national WLAN roaming agreements so far
- Unified roaming tariffs announced within Europe (11 countries, GSM voice call 0.95€/min)