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

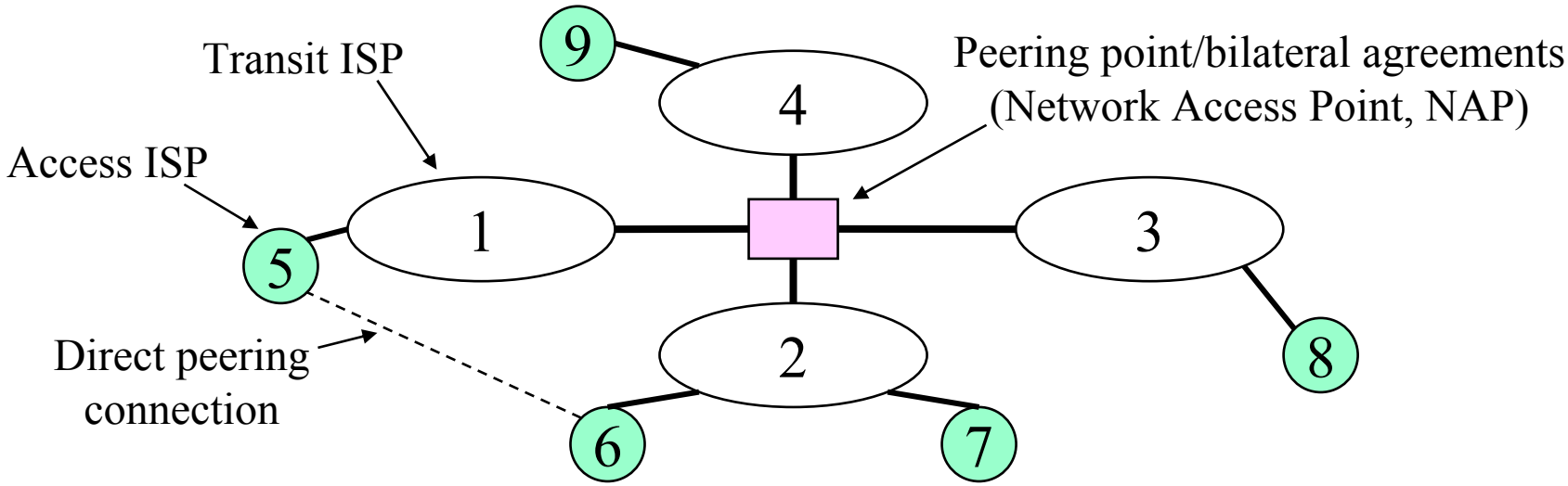
Mobile Virtual Network Operators (MVNO) can survive if

- 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

Interconnection

Business interfaces in Internet



- Business interfaces are technically managed via accouncements 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?

Source: Courcoubetis, Weber, 2003

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

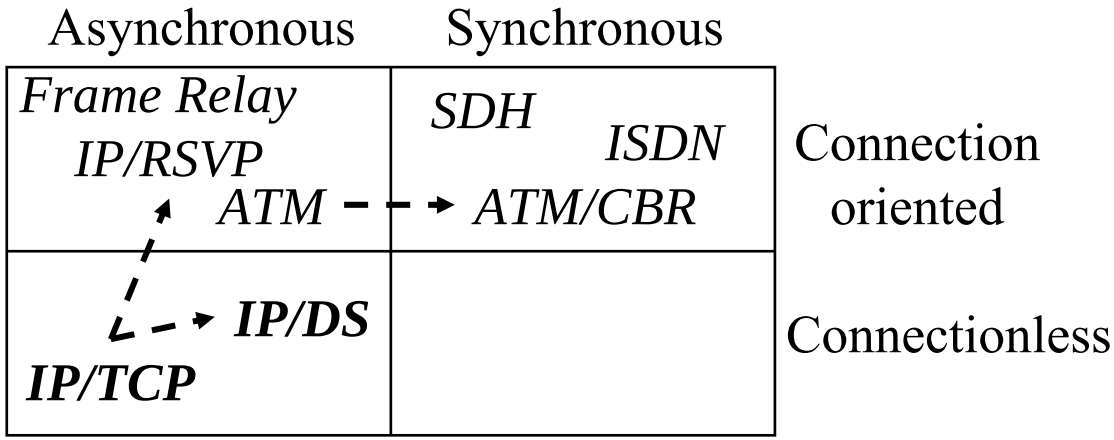
Interconnection

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

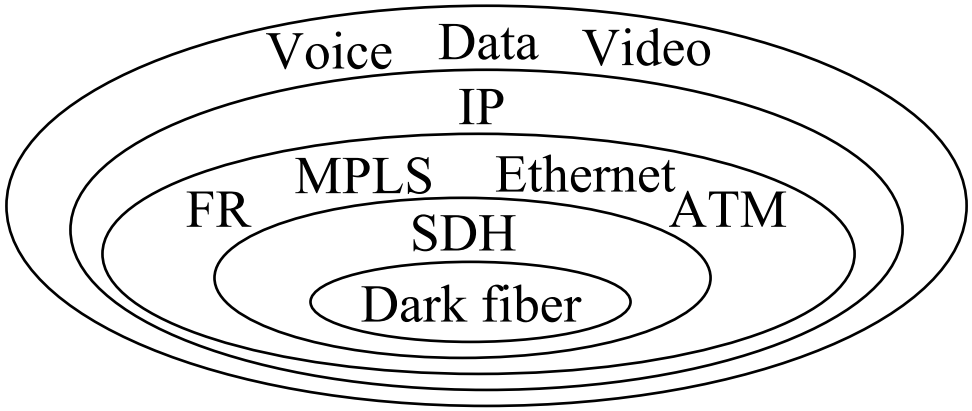
Impact of IP



- 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

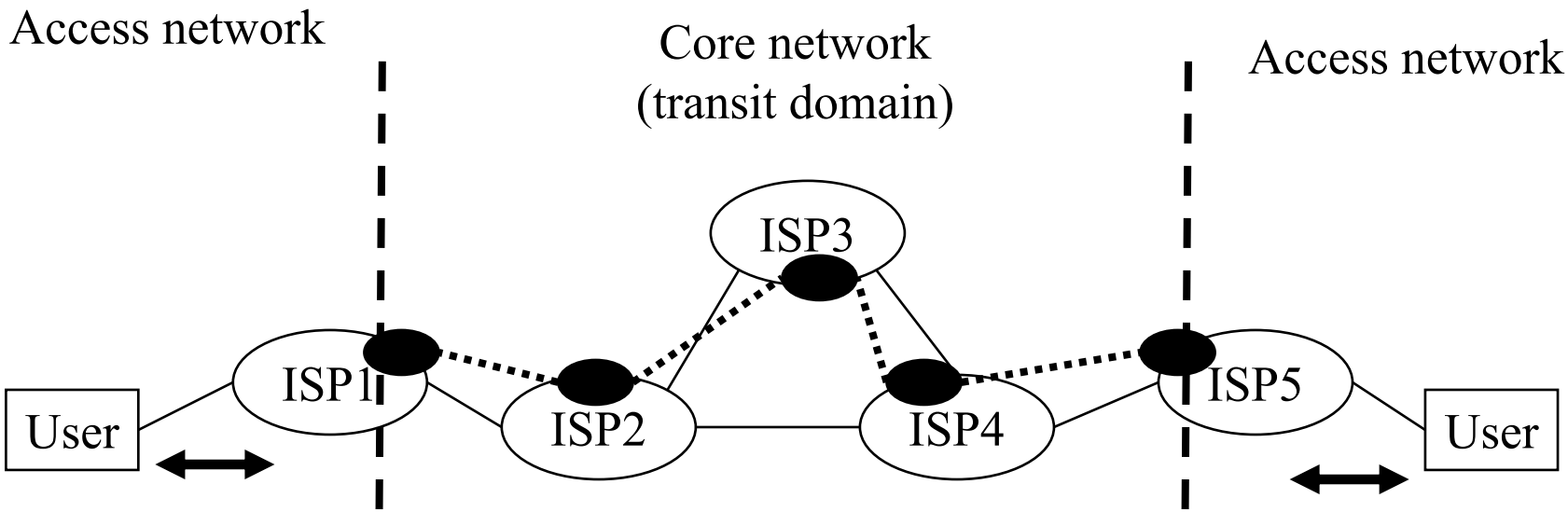
1. Static SLA management in telecom networks and dedicated data networks
2. Static SLA management in IP-based best effort networks
3. Static SLA management in IP diffserv (DS) networks ?
4. Dynamic SLA management in IP DS networks ?

DS has the following SLA characterictics

- 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

Backbone services

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

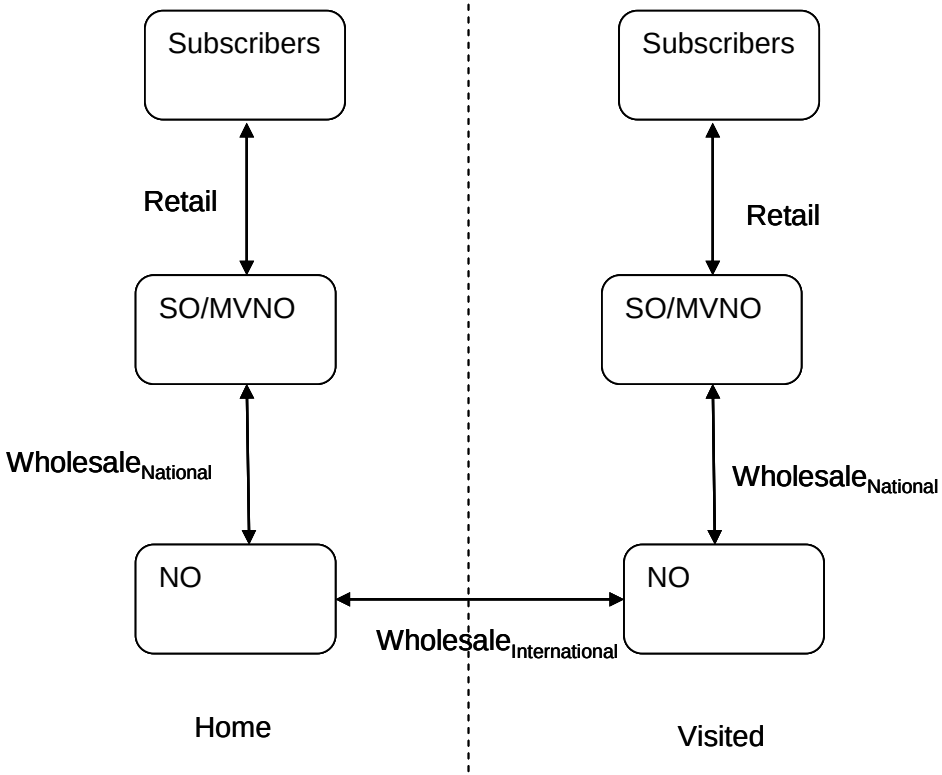
EU is adding pressure on roaming prices

- 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$_{National}$:between service operator (SO) or MVNO with the national network operator (NO)
- Wholesale$_{International}$: between NOs (home and visited) which is typically international in nature.

Importance of Roaming

World

Arrivals by purpose of visit (including estimations for countries with missing data)

	International Tourist Arrivals (million)				Market share (%)		Growth rate (%)		Average annual growth (%)
	1990	1995	2000	2001	1990	2001	00/99	01/00	1990-2000
Total	455.9	550.4	687.3	684.1	100	100	6.8	-0.5	4.2
Leisure, recreation and holidays	284.0	339.1	371.1	367.0	62.3	53.6	7.0	-1.1	2.7
Business and professional	57.8	80.1	130.9	128.4	12.7	18.8	6.5	-1.9	8.5
VFR, health, religion, other	74.4	106.5	154.6	161.8	16.3	23.6	6.9	4.6	7.6
Not specified	39.8	24.8	30.6	27.0	8.7	3.9			

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

($ millions)	Intra-continental Roaming		Inter-continental Roaming		Total Roaming Revenues		Total Service Revenue		Roaming as a % of Total Revenue	
	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
Europe	$15,973	$16,546	$465	$1,670	$16,438	$18,216	$99,046	$137,038	17%	13%
North America	1,011	1,543	68	1,513	1,079	3,057	80,881	168,255	1%	2%
Asia Pacific	1,211	1,404	65	887	1,276	2,291	96,877	151,893	1%	2%
South America	175	229	47	400	221	629	17,491	27,424	1%	2%
Total	$18,370	$19,723	$644	$4,470	$19,014	$24,192	$294,294	$484,609	6%	5%

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

		FYE
Revenue - Outbound		
Unique Subscribers		35,000
Avg. # of Visits per Year		2
Avg. # of Days per Visit		5
Avg. # of Calls per Day		5
Avg. # of Minutes per Call		3
Avg. Price per Minute		$2.00
Subtotal - Outbound Revenue		$10,500,000
Revenue - Inbound		
Unique Subscribers		15,000
Avg. # of Visits per Year		2
Avg. # of Days per Visit		5
Avg. # of Calls per Day		5
Avg. # of Minutes per Call		3
Avg. Price per Minute		$1.00
Subtotal - Inbound Revenue		$2,250,000
Gross Int'l Roaming Revenue		$12,750,000
Less: Bad Debt	5%	$637,500
Net Int'l Roaming Revenue		$12,112,500

Expenses			
Cost of Service			
Inter-Operator Tariff - Outbound Roaming		$5,250,000	
Network Cost per MOU - Inbound Roaming		$45,000	
Signaling			
Rental of Lease Line for Frame Relay		$12,000	
3rd Party Processing/Routing Service		43,750	
Total Signaling Cost		$55,750	
Financial Settlement			
3rd Party Message Processing		$28,000	
CIBER/CIBERNET License Fee		$87,188	
Total Financial Settlement Cost		$115,188	
Fraud Management			
RoamX		$3,750	
Subtotal - Cost of Sevice		$5,469,688	
Gross Margin		$6,642,813	55%
SG&A		$3,028,125	25%
EBITDA		$3,614,688	30%
Depreciation of Non-recurring Expenses		$33,333	
EBIT		$3,581,354	30%

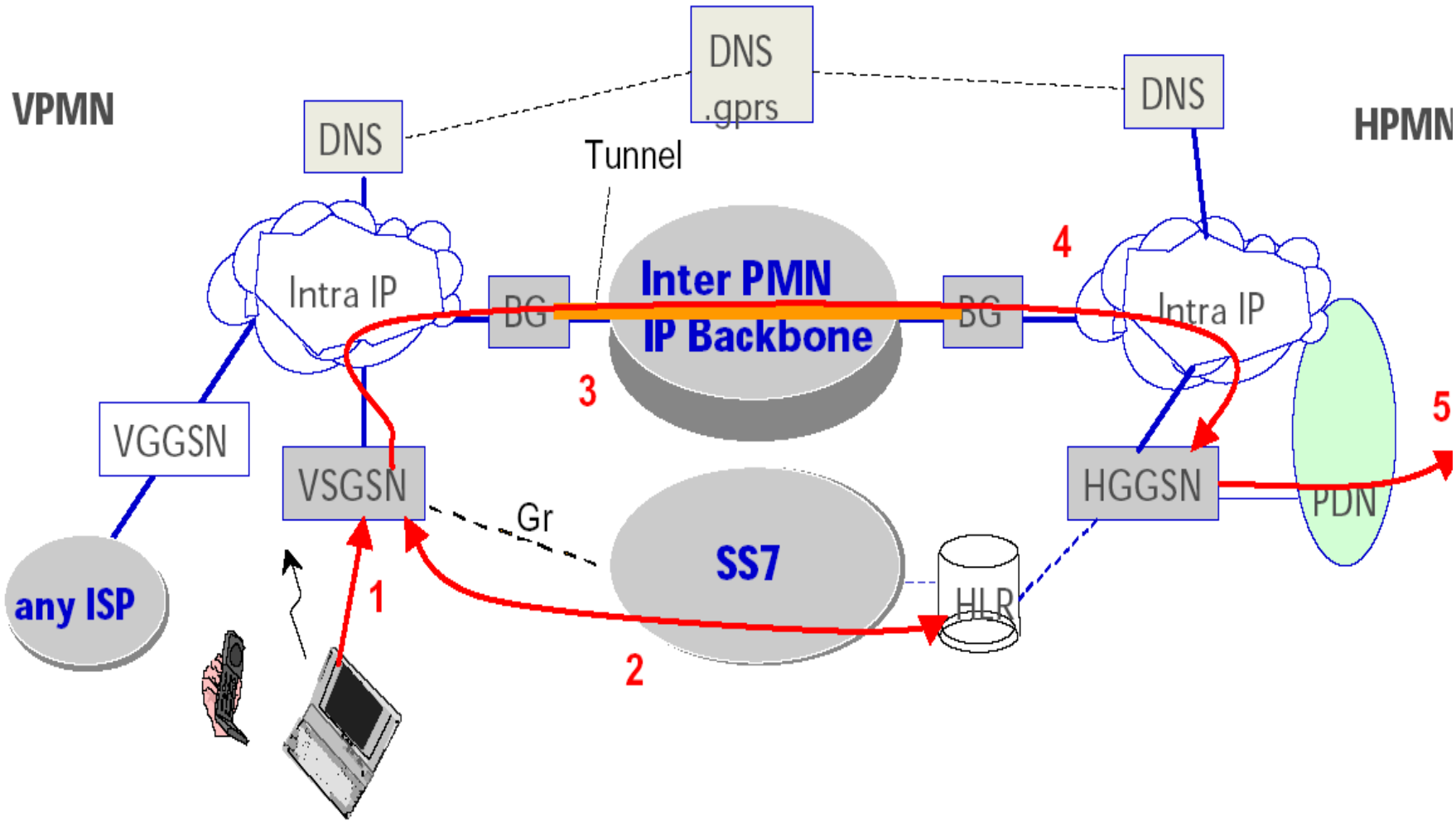
Note: Estimated costs for a generic CDMA operator

- 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

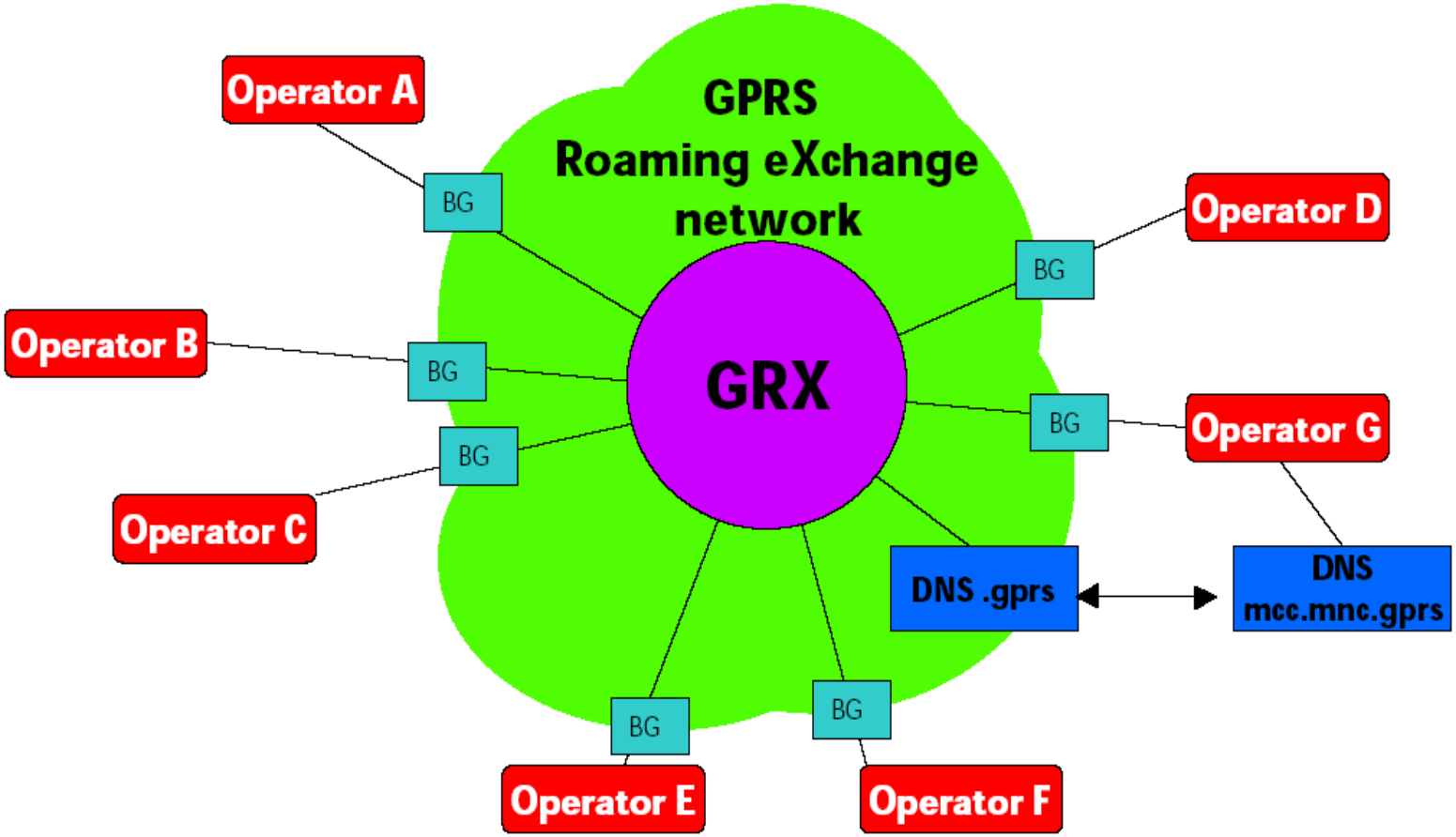
Technical Architecture - Bilateral



Source: Renjish Kaleelatzicathu, 2004

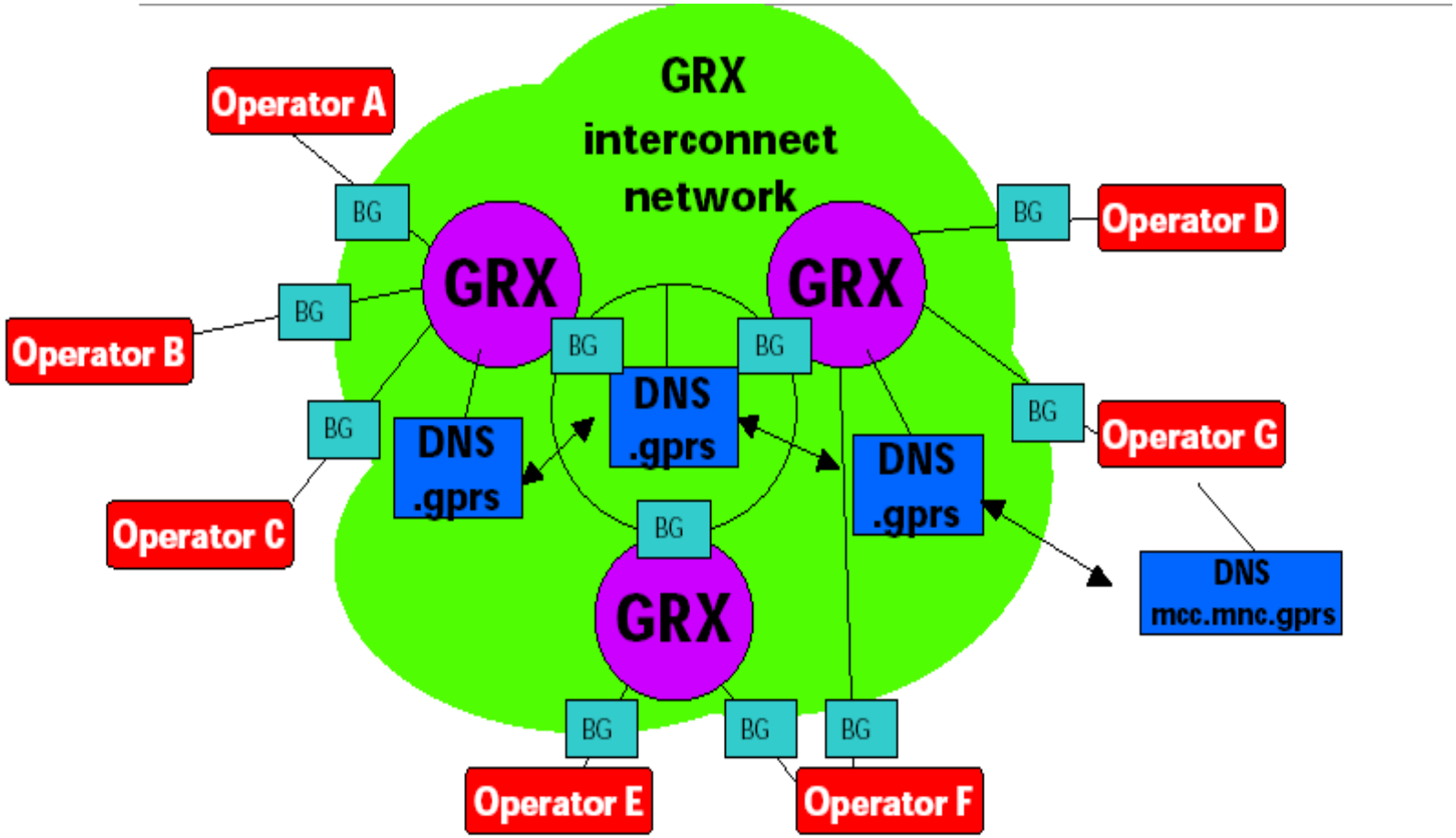
GPRS Roaming

Technical Architecture – Single GRX



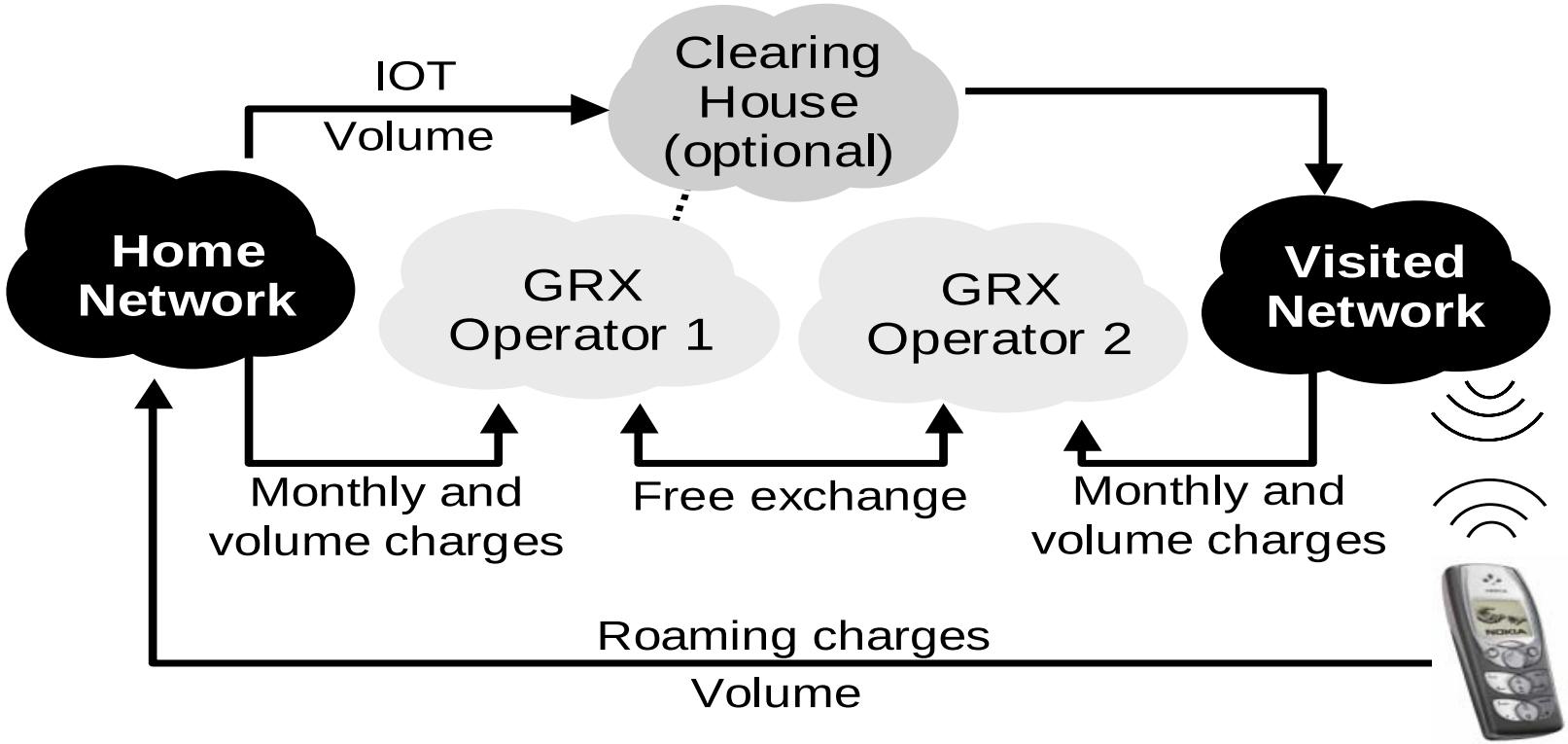
GPRS Roaming

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

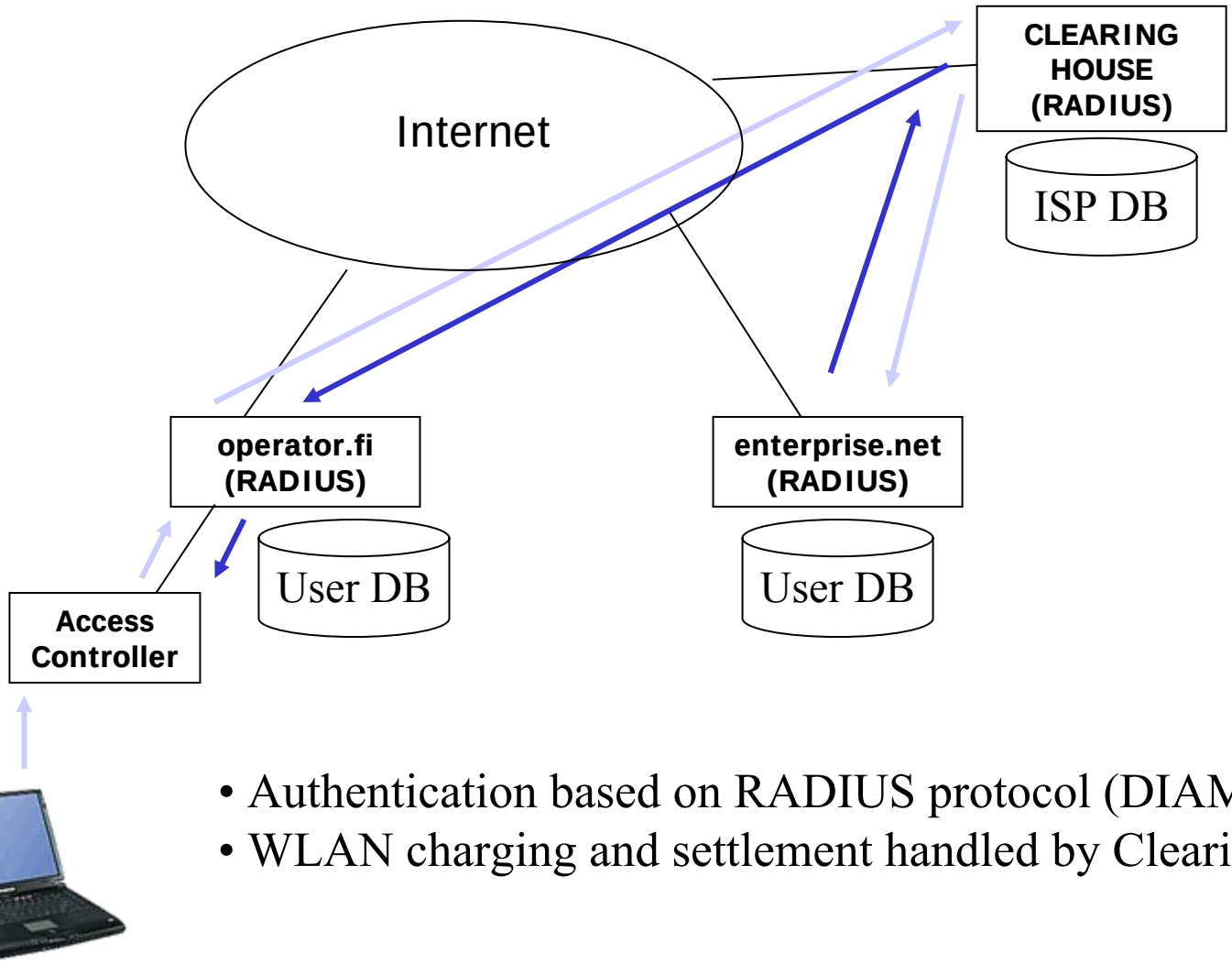
Business Model Scenarios: Bilateral, Clustered, Centralized

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

- 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

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

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

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

  $\Rightarrow$ no national WLAN roaming agreements so far
- Unified roaming tariffs announced within Europe (11 countries, GSM voice call 0.95e/min)