KUNGL TEKNISKA HÖGSKOLAN
Institutionen för mikroelektronik och informationsteknik

2G1330 Mobile and Wireless Network Architectures

Number portability, VoIP, Prepaid

Lecture notes of G. Q. Maguire Jr.

For use in conjunction with *Wireless and Mobile Network Architectures*, by Yi-Bing Lin and Imrich Chlamtac, John Wiley & Sons, 2001, ISBN 0-471-39492-0

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Lecture 4

- Number portability (Ch. 15), VoIP (Ch. 16), Prepaid (Ch. 17)

Database lookups

Local Number Portability (LNP)

Local Number Portability is required by the Telecommunications Act of 1996 and a July 1996 order of the Federal Communications Commission (FCC) - similar requirements in Sweden and else where.

LNP (as defined by the FCC): “the ability of users of telecommunications services to retain, at the same location, existing telecommunications numbers without impairment of quality, reliability, or convenience when switching from one telecommunications carrier to another.”

LNP implies efficient call-routing must **not be based** on a **physical** location, but rather a **logical routing scheme** for how and where to route a call.

Verizon’s cost recovery for providing LNP amounts to US$13.80/line over a 5 year period!

Three kinds of Local Number Portability

- Service Provider Portability: subscriber can move to an new provider without a change in number (current requirement)
- Location (or Geographic) Portability (GNP): subscriber can move to a new location/geographic area (future requirement)
- Service Portability: if the service (mix) which the subscriber has is not available in their new local exchange -then connect them to where the services are available (future requirement)

Mobile Number Portability (MNP)

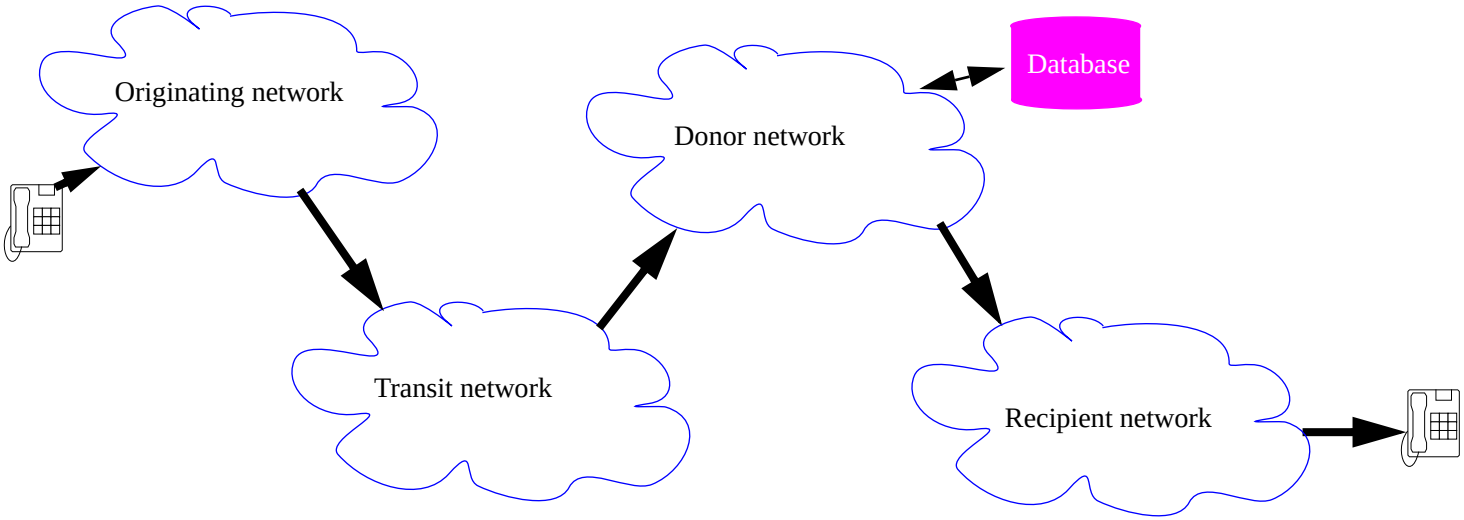
requirement that any mobile (e.g., GSM) subscriber be able to move to a new **operator** or **service provider** and keep the same number (MSISDN)

Non-geographic number portability (NGNP)

numbers (typically) associated with a service rather than a geographic destination, e.g., freephone, low rate calling numbers, premium rate numbers; requires that the service provider can be changed without a change of number; these all require DB lookup

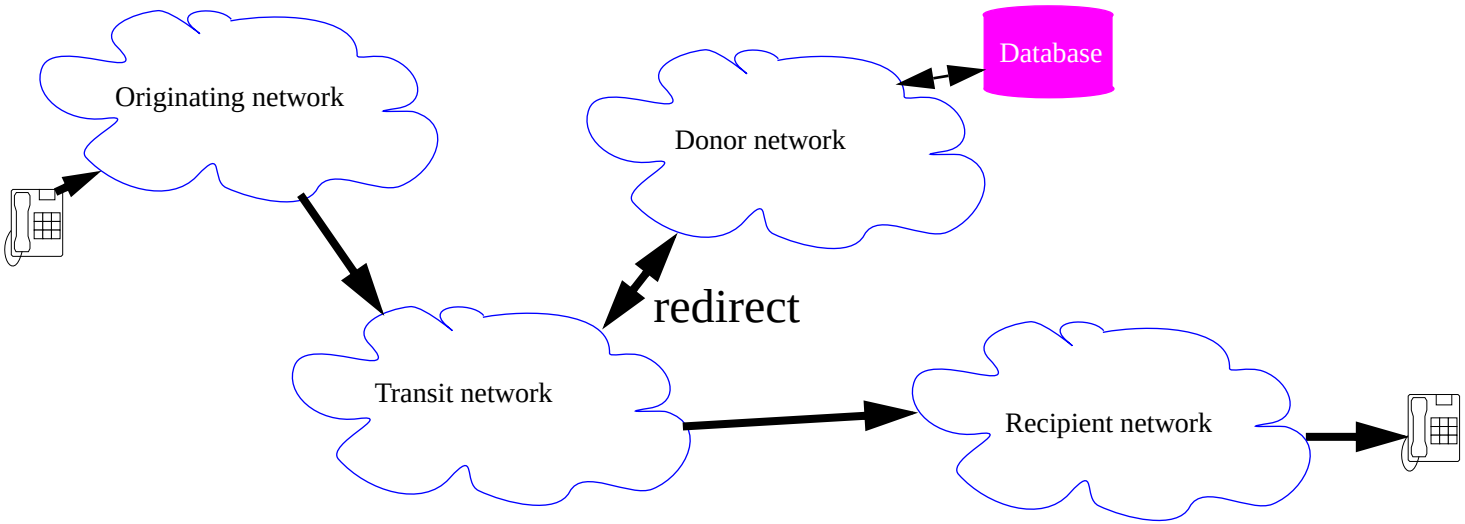
Call forwarding at donor end

donor -- service provider from whom the number is initially associate



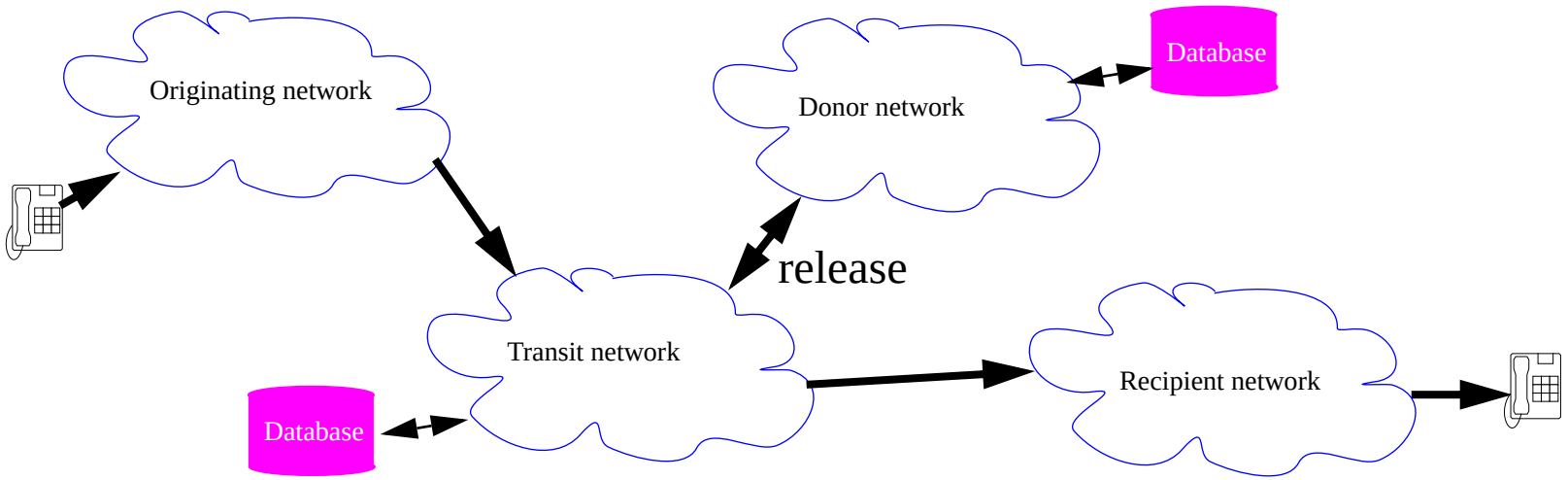
- inefficient in terms of call setup delays and usage of transmission capacity
- cannot easily cope with numbers ported more than once, and
- the donor network continues to control first and subsequent portings.

Drop back forwarding



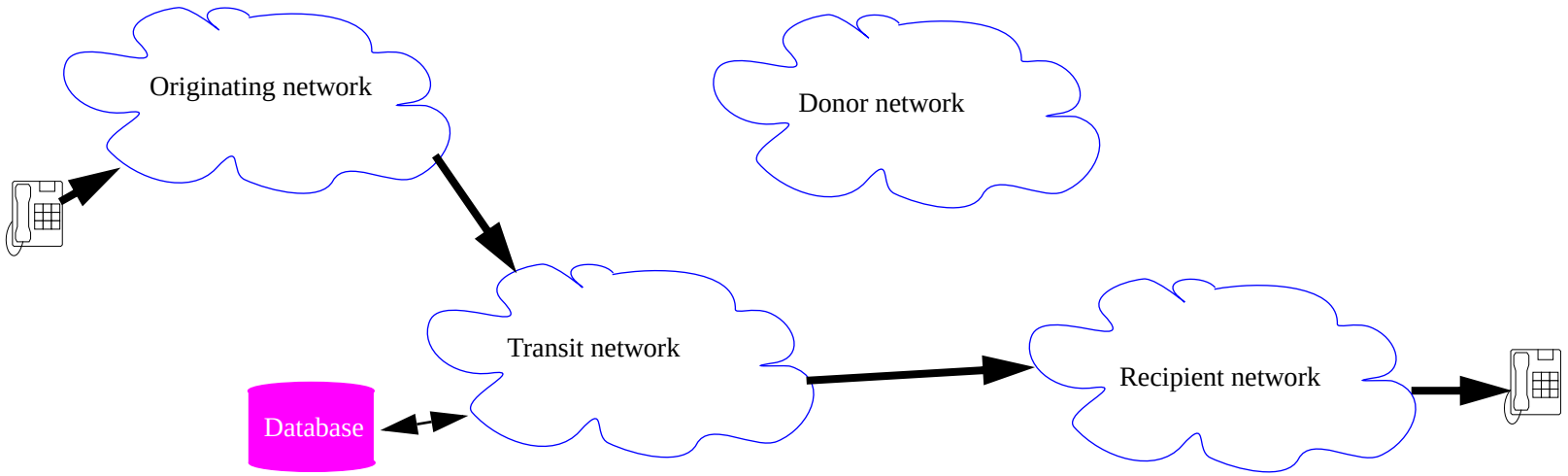
- transit network gets a redirect from the donor network, it may be ablt to pass this all the way back to the originating network (i.e., dropping back through each of the networks to the originating network)
- makes better use of transmission capacity and can handle multiple portings
- the donor network continues to control first and subsequent portings.

Query on release (QoR) solutions



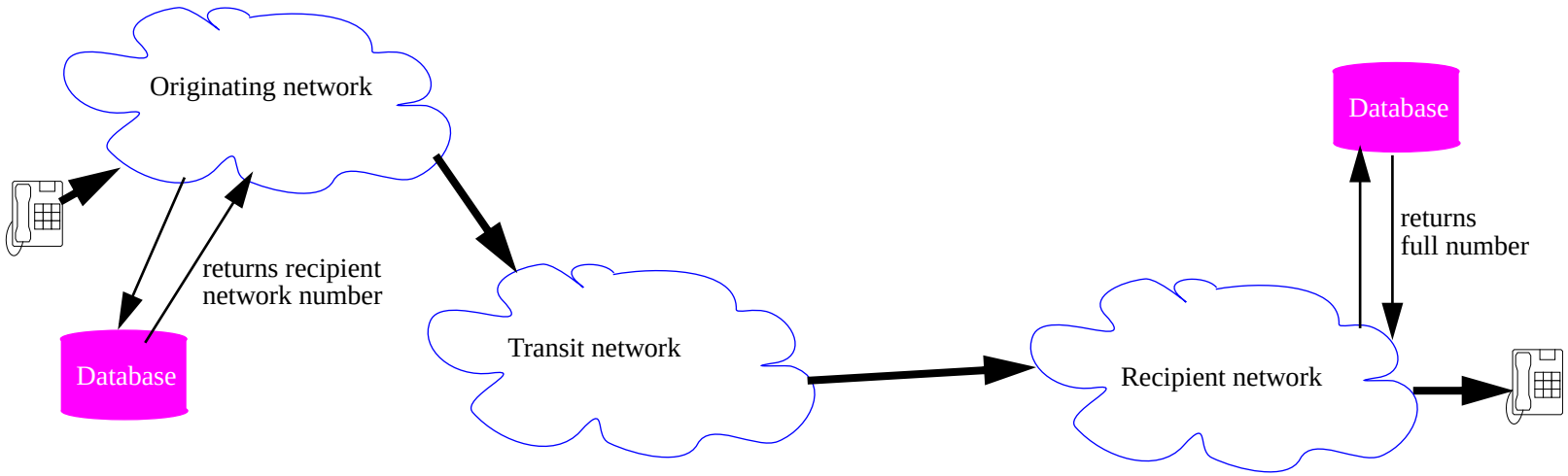
- donor network realises the number has been ported out and sends an ISUP release or it might not know anything about this number (i.e., not it its DB any longer) ⇒ releases the call
- release causes an intermediate point to query a portability database and to redirect the call.
- If the forward signalling indicates that preceding networks have QoR capability, then the release goes all the way to the originating network, which does the DB lookup and reroutes the call to recipient network.

Look up type solutions



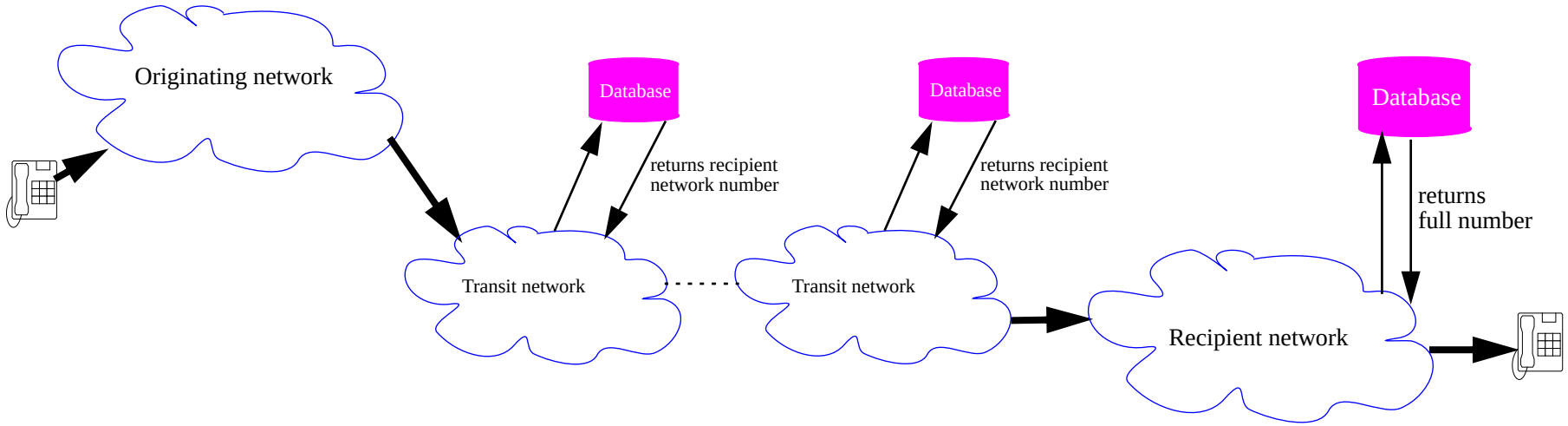
- portability database is checked for **all** calls, if the number has been ported, the new number is obtained and the call rerouted (done at first **first exchange** in a network that can access a **portability database**)
- solution is often implemented in North America via modified Signalling Transfer Points (STPs) which can check and translate ported numbers by modifying call setup information
- the donor network now has no role, multiple portings easy; but requires lookup of all numbers

Two stage solutions



- originating network simply learns the recipient network's number (called a Logical Routing Number (LRN), in North America this is a unique 10 digit number for the exchange)
- recipient network does a second lookup to determine where to deliver the call within their network
- increases the privacy (since the originating network does not learn about the recipient network numbering)

All call/all network solutions



- each network does a lookup, but simply learns the “next” network’s number
- final recipient network does a second lookup to determine where to deliver the call within their network
- increases the privacy -- since all networks along the path only learn about the “next” network

Who knows the mappings?

Who knows the mappings?

For North America the Number Portability Administration Center (NPAC) has all the mappings and passes then to the operator's Local Service Management System (LSMS).

Nummerportabilitet i Sverige

- Europaparlamentets och rådets direktiv 98/61/EG om nummerportabilitet
- Sverige ändringar i telelagen (1993:597) 1 juli 1999
- Post- och telestyrelsen (PTS) om nummerportabilitet (PTSFS 1999:3 och PTSFS 2000:6).
- PTS beslut 15 augusti 2001 (ärende nr. 01-19102):

Swedish Number Portability Administrative Centre AB (SNPAC)

Peter Myndes Backe 12

118 46 Stockholm

(organisationsnr. 556595-2925)

http://www.pts.se/dokument/getFile.asp?FileID=2384

EU Document 398L0061

[13.20.60 - Information technology, telecommunications and data-processing]

[13.10.30.20 - Research sectors]

Instruments amended:

397L0033 (Modification)

398L0061: Directive 98/61/EC of the European Parliament and of the Council of 24 September 1998 amending Directive 97/33/EC with regard to operator number portability and carrier pre-selection

Official Journal L 268 , 03/10/1998 p. 0037 - 0038

http://europa.eu.int/eur-lex/en/lif/dat/1998/en_398L0061.html

Nortel Networks' Universal NP Master (UNMP)

A complete end-to-end number portability (NP) solution provides:

- Number Portability Database (NPDB) and Number Portability Global Title Translation (NPGTT) functionality as a single network element
- Local Service Management System (LSMS) for the management of the ported subscriber records
- support: AIN/IN and IS41 protocols for wireline and wireless porting services
- up to 11-digit GTTs for wireless number porting
- up to five million ported number records.
- Ported number service support includes Calling Name, CLASS, Inter-switch Voice Messaging, Line Information Database, Short Message Service, and PCS Call Delivery services.
- 5,000 queries per second, with planned expansion to 20,000 queries per second.

Lookup engines

Aeroflex UTMC (*http://www.utmc.com/ecard*) LNP-Engine (cPCI or PCI board):

- Stores up to 160 million 16-digit phone number pairs
- Supports 100K lookups and 10K updates per second

Based upon two Content Addressable Memory Engines:

- custom 100 MHz chip
- lookup in as little as 100 nanoseconds
- partitions memory into upto 8,192 tables, from 256 to 30 million records
- programmable key widths (per table): from 1 to 32 bytes
- programmable association widths (per table) up to 8 megabytes
- performs exact matches, as well hierarchal, longest-prefix, and proximity matches
- pipelined operation with separate I/O FIFOs
- bulk table load, unload, and count functions
- handles table overflows

VoIP

Integrating VoIP with mobile telephony

TIPHON

ETSI's Telecommunication and Internet Protocol Harmonization over Network (TIPHON)

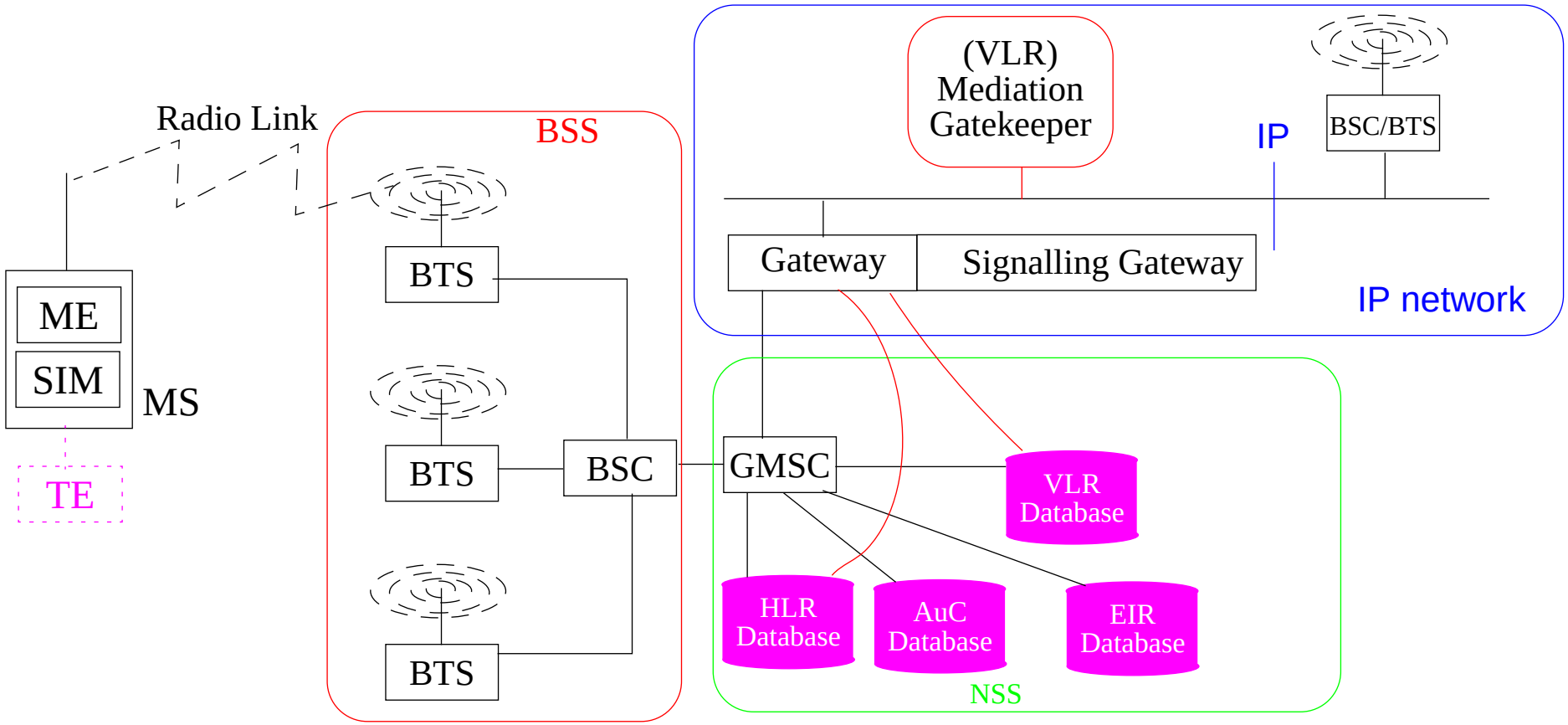


Figure 1: TIPHON Architecture

Ericsson's GSM on the Net

ETSI's Telecommunication and Internet Protocol Harmonization over Network (TIPHON)

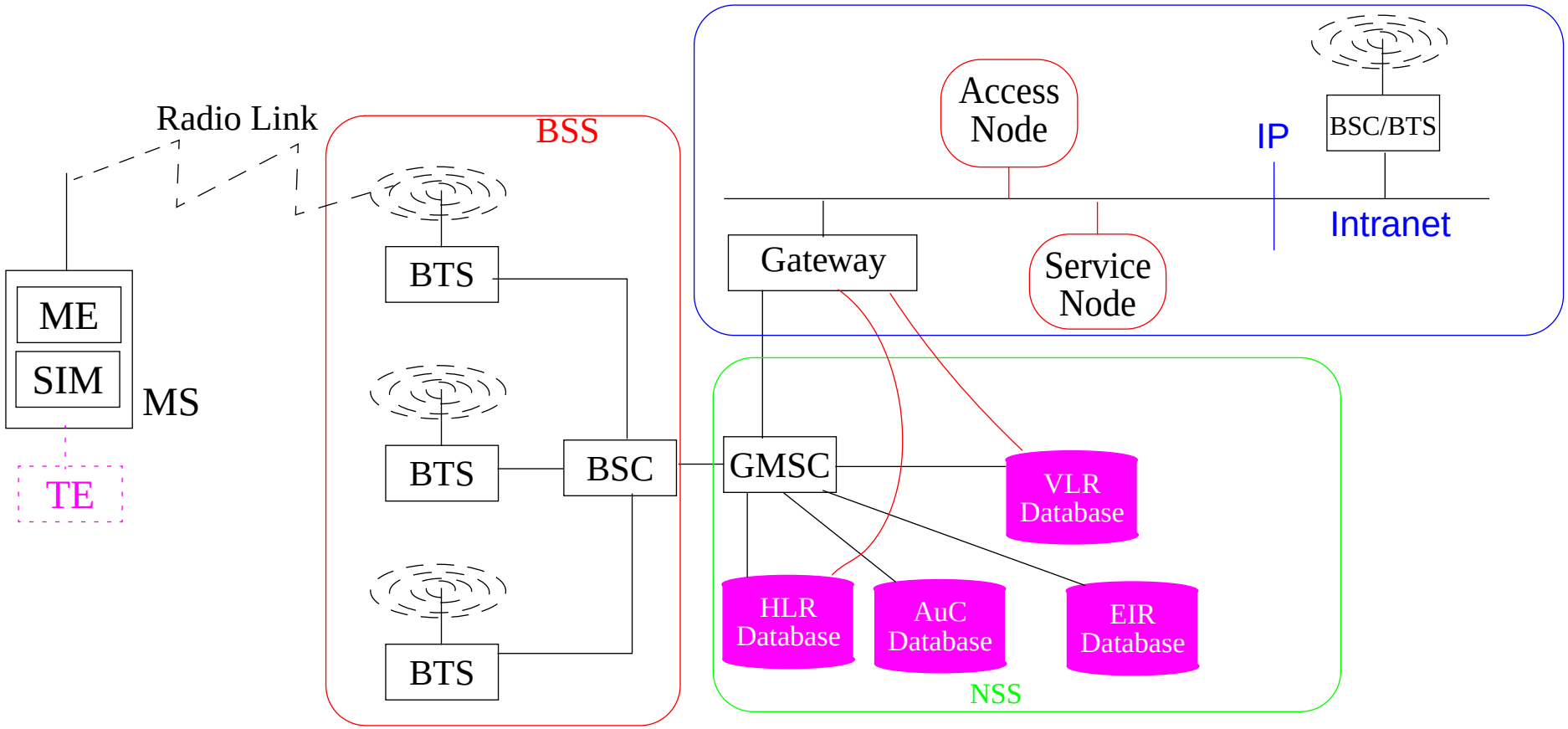


Figure 2: Ericsson's GSM on the Net Architecture

iGSM

Proposed by Yi-Bing Lin and Imrich Chlamtac in section 16.2.

This architecture is really a joining of H.323 with a gateway to GSM.

Prepaid

Customer pays **before** using service.

Advantages:

- operator has the money - all up front (**no risk** and they can even earn interest on it)
- operator **saves**: no need for: credit checking, invoices, collections, …
- customer: no need for credit worthiness, no need for a contract, immediate service, anonymous service is possible
- since for many cultures and countries there is no tradition or infrastructure for post-paid service - business is strictly cash up front -- prepaid fits well with the expectation of these customers
- prepaid value can be installed in devices (such as toys, jewlery, …)
- many customers will never use up all their balance - it will simply be abandon -- much to the delight of the operator {It is “like printing money”!}

GSM Prepaid

Prepaid credit is either kept in the SIM card or in the network.

When the balance is zero, customer can only receive calls. {this may be limited by the operator}

To refill:

- customer buys a refill/top-up card with a secret code
- dials a freephone number to an Interactive Voice Response server
- enters MSISDN number of their phone + secret code
- system verifies secret code (so code can only be used once), then refills the account

Difference between Mobile and Fixed Prepaid

Mobile servers needs:

- more complex billing system due to more complex **tariffs** (which can be location dependant!)
- more complex billing system due to more complex **taxation** (which can be location dependant!)
- real-time usage metering - which has to cut off service when balance is zero (there is a trade off between accuracy and cost of implementation - if the operator is willing to take some loss, the implementation can relax the real-time constraints)
- increased complexity of customer care: warning customer to refill in a timely fashion (maintaining a credit balance - maintains cash at the operator!)

Four alternatives for Mobile Prepaid

- Wireless Intelligent Network (WIN)
- Service Node
- Hot Billing
- Handset-Based

Wireless Intelligent Network (WIN)

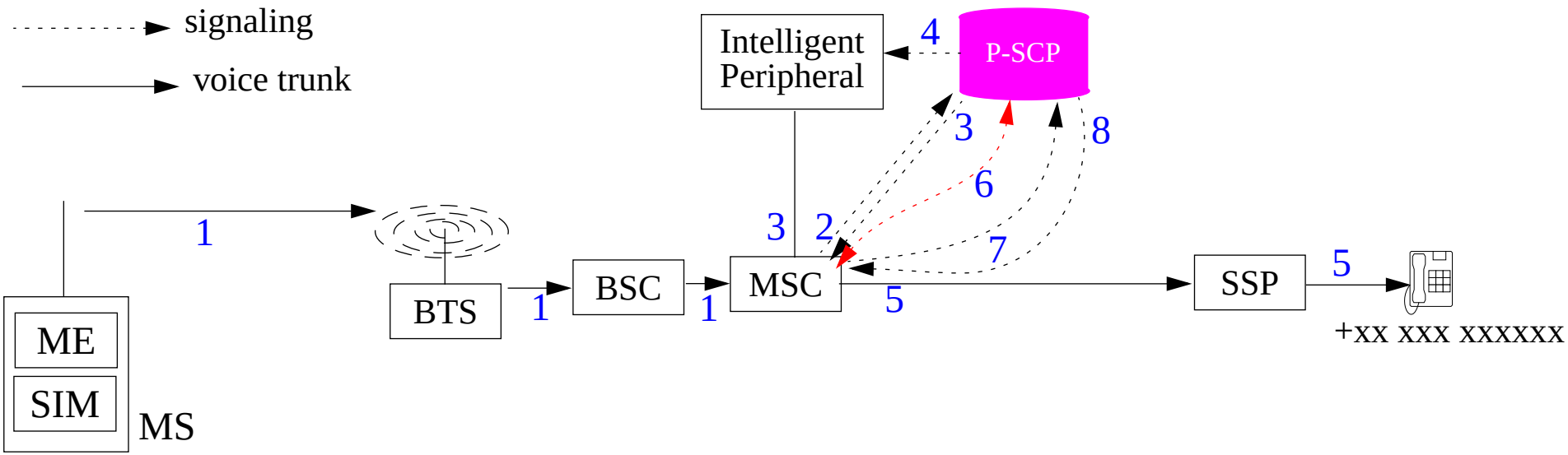


Figure 3: WIN Prepaid call origination

1. Prepaid mobile customer calls +xx xxx xxxxxx
2. MSC gets WIN call setup trigger, call setup suspended, message sent to Prepaid Service Control Point (P-SCP)
3. P-SCP instructs MSC to set up ISDN (voice) link to intelligent periperal
4. P-SCP instructs intelligent periperal to provide **account status notification** (balance, charging rate, …) for this call
5. P-SCP starts countdown timer & instructs MSC to resume call processing -- which connects the call
6. Call terminates: either (a) countdown timer expires (P-SCP instructs MSC to terminate call) or (b) call completes
7. MSC gets WIN call release trigger, sends disconnect message to P-SCP indicating duration of call
8. P-SCP rates the call (computes charges) and debits the prepaid balance, sends current balance and cost of call to MSC

Calling party pays vs. Called party pays

Calling party pays style billing - Europe, Taiwan

Called party pays style billing - US (where mobile subscriber pays for ***both*** incoming and outgoing calls)

WIN Call termination when called party pays

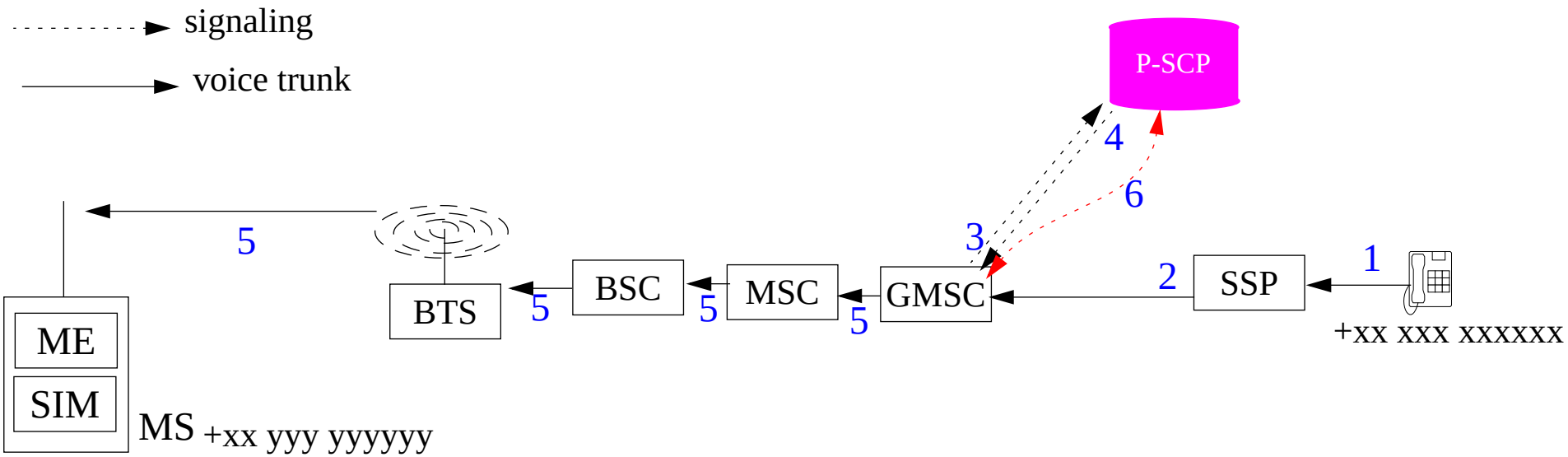


Figure 4: WIN Prepaid call termination

1. Caller dials prepaid mobile customer +xx yyy yyyyyy
2. Call forwarded to gateway GMSC
3. GMSC get a WIN call setup trigger, suspends call processing, sends message to P-SCP
4. P-SCP determines if mobile is allowed to receive this call, if so instructs GMSC to resume call setup procedure
5. GMSC connects the call
6. P-SCP monitors called party's balance and can terminate the call if there is no credit (just as per call origination case)

Service Node

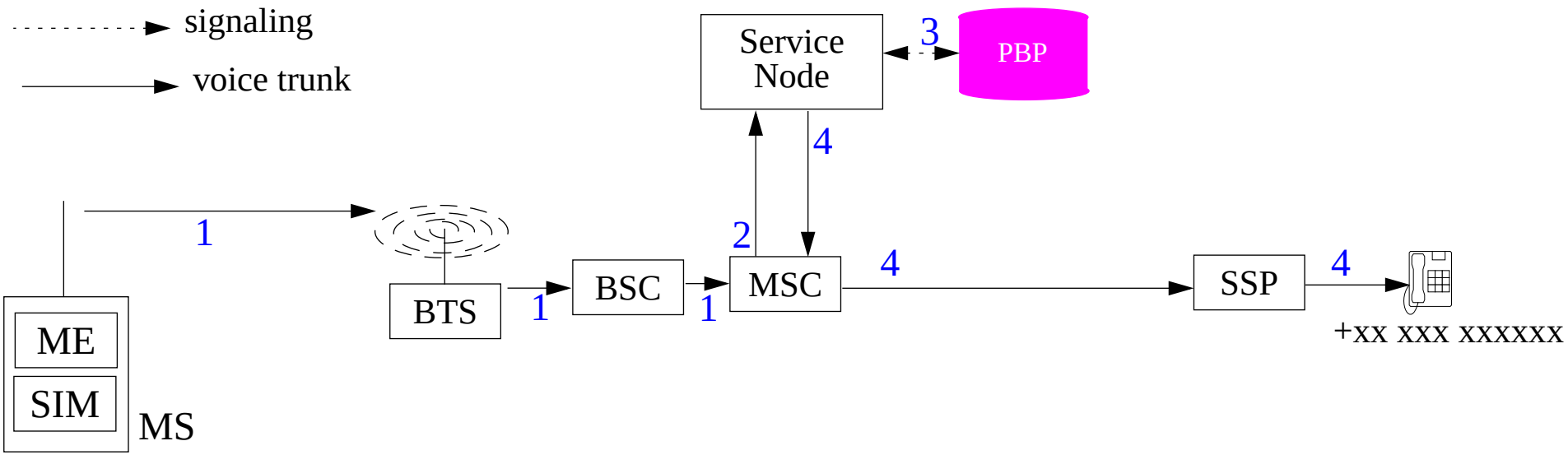


Figure 5: Service Node Prepaid call origination

1. Prepaid mobile dials called party (+xx xxx xxxxxx)
2. MSC detects this is a prepaid customer and sets up trunk to service node
3. Service node consults Prepared Billing Platform (PBP) to determine if the call should be allowed
4. If so, then a 2nd trunk is setup from the service node via the MSC to the called party

Note: at the cost of the 2nd trunk (and two ports of MSC), this is a very easy service to build - since the MSC does not actually know about the prepaid service - only that it is to connect calls from these customers to the service node.

Hot Billing

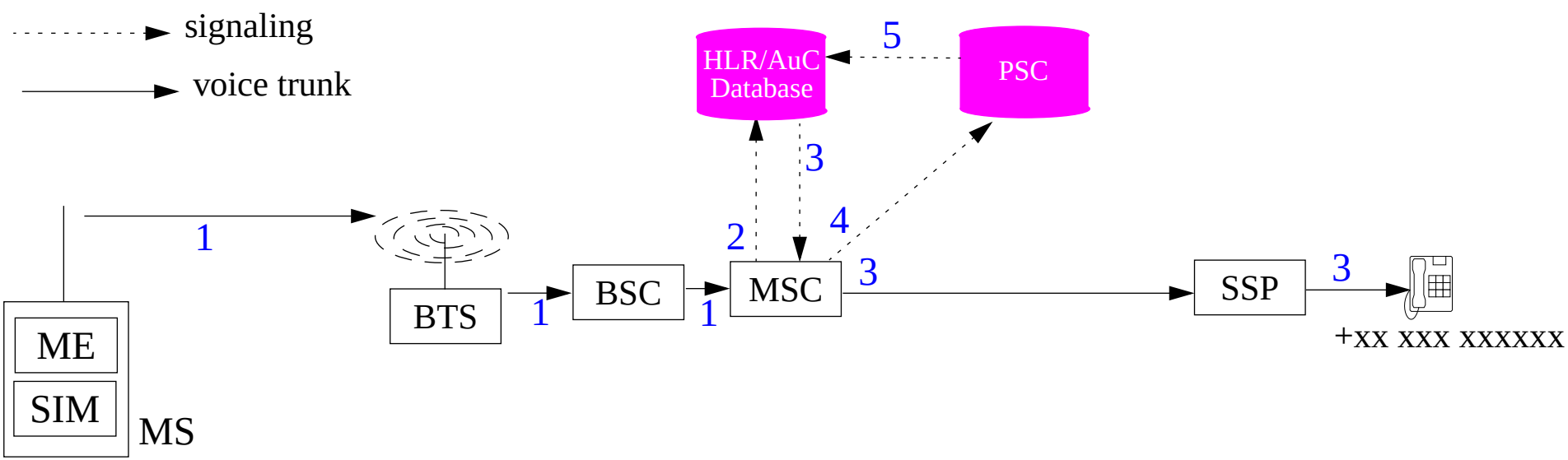


Figure 6: Hotbilling Prepaid call origination

1. Prepaid mobile dials called party (+xx xxx xxxxxx) and sends their own IMSI
2. Based on IMSI, MSC asks HLR/AuC if this is a valid service request
3. If verified, HLR/AuC sends customer data and a prepaid tag to MSC, MSC connects call
4. When call terminates, a Call Detail Record (CDR) is sent to the Prepaid Service Center (PSC)
5. PSC debits the account, if the account is out of funds it notified the HLR/AuC to supsend service!

With hot billing the operator is taking a risk (of the cost of the call exceeding the balance), but it is a "**one-call exposure**" and reduces the complexity of the system.

“**one-call exposure**” in depth

Since the operator may have no idea of who this cusomter is, they have no way of collecting on the “bad debt”, thus they try to avoid it:

- Use large values for the initial payment and refill/top-up - thus the account has quite a ways to go before it is depleted (i.e., no low value prepayments)
- prohibit call forwarding to prepaid accounts (since otherwise you could simultaneously forward lots of calls through a given prepaid account at one time and “one-call” suddenly becomes “N-calls”!)
- increase the interval at which CDRs are sent for processing {but this costs in increased load on the PSC} -- in fact the trend is towards the opposite, send bunches of CDRs are one time rather than in “real-time” as calls end {this decreases load on PSC, but increases bad debt exposure} -- in the end it is a business decision of risk/reward

Handset-Based

Uses GSM Phase 2, Advice of Charge (AoC):

- Advice of Charge Charing (AoCC) ⇐ this is how you debit the balance in the SIM card
- Advice of Charge Information (AoCI)

Builds upon sever SIM data fields:

- accumulated call meter (ACM)
- accumulated call meter maximum (ACM*)
- price per unit and currency table (PUCT)

Prepaid service center (PSC) uses SMS messages to execute program in the handset, these applications are controlled by the SIM Toolkit.

Different sized SIM cards may be needed if large tariff rate tables or complex rating schemes are to be used.

ACM and ACM* are generally user accessible (via PIN2), but for prepaid cards this access is disabled (either at time of manufacture or via an SMS message when users subscribes to prepaid service).

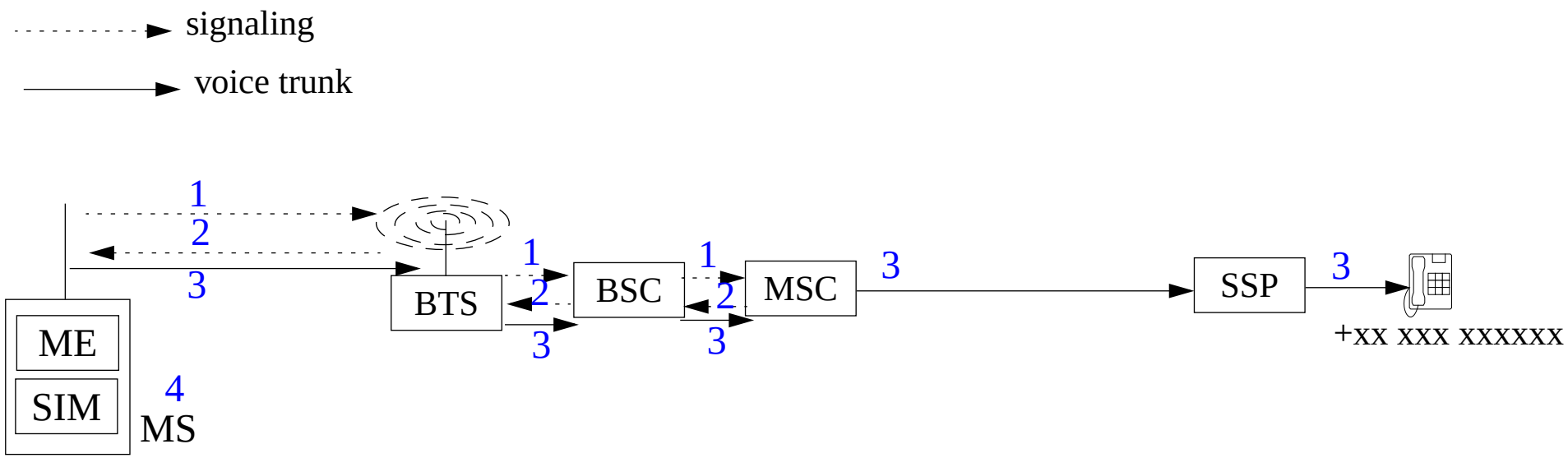


Figure 7: Handset-Based Prepaid call origination

1. Prepaid mobile dials called party (+xx xxx xxxxxx)
2. Based on rate plan (+ destination, time/date), MSC sends AoC e-parameters (including ACM and ACM*) to mobile
3. If mobile support AoCC, it acks receipt of e-parameters; if MSC gets this ack, call is connected, otherwise call is denied
4. During call MS uses AoC e-parameters for tariff info; locally decrements credit by incrementing ACM. When ACM reaches ACM*, MS terminates call and informs MSC of call release

Combined Handset-based + Hot Billing

For fraud reduction, Handset-based approach can be combined with the Hot billing approach - thus if PSC thinks there is no credit but SIM claims credit, the PSC can inform operator to: terminate service and/or trigger fraud investigation.

Unfortunately, the disagreement might be legitimate due to poor synchronization (of charging information) between PSC and MS.

Roaming and Prepaid

Lots of problems:

- can’t easily use special MSISDN numbers as this would:
  - prevent operator number portability
  - service portability is not allowed, since you could not change to post paid without changing MSISDN
  - could use IMSI, but this might require software change at visited system
- prepaid charging might not be performed at visited system (because it uses a different prepaid scheme than home system)
  - therefore route the call via the home system - letting it implement the prepaid debiting
  - but this requires a trunk to the home system (⇒ higher charge for a specific prepaid call than a postpaid call) -- this may be too expensive for international roaming
- scalability problems with service node approach (since you use up two MSC ports per call)
- AoC traffic is not encrypted - so the handset can just tamper with or ignore debit commands! ⇒ manufactures working on SIM encryption
- handset-based approach may lock operator to a SIM supplier
- some of the schemes have a high setup cost

Further reading

Number portability

[1] Tango Telecom (*www.tango.ie*),"Number Portability: a white paper", Tango Telecom, wpnp01-18/02/00, *http://www.tango.ie/wpnp01.pdf*

[2] Barry Bishop, "LNP, Pooling and IVR: What are the impacts to Public Safety Organizations and Law Enforcement?", Lockheed Martin, *http://www.numberpool.org/law_911_registration/apco.ppt*

[3] North American Number Portability Administration Center (NPAC) (*http://www.npac.com*)

VoIP

[4] see course notes for 2G1305, Internetworking *http://www.it.kth.se/edu/gru/Internet/Coursepage-Spring-2002.html*

Prepaid

[5] Gemplus, "Smart Card in Wireless Services", {perhaps a bit biased since they are one of the leading vendors of smart cards}

http://www.portaltele.com.br/files/smartcard.pdf