Locating Mobile Phones using Signalling System #7

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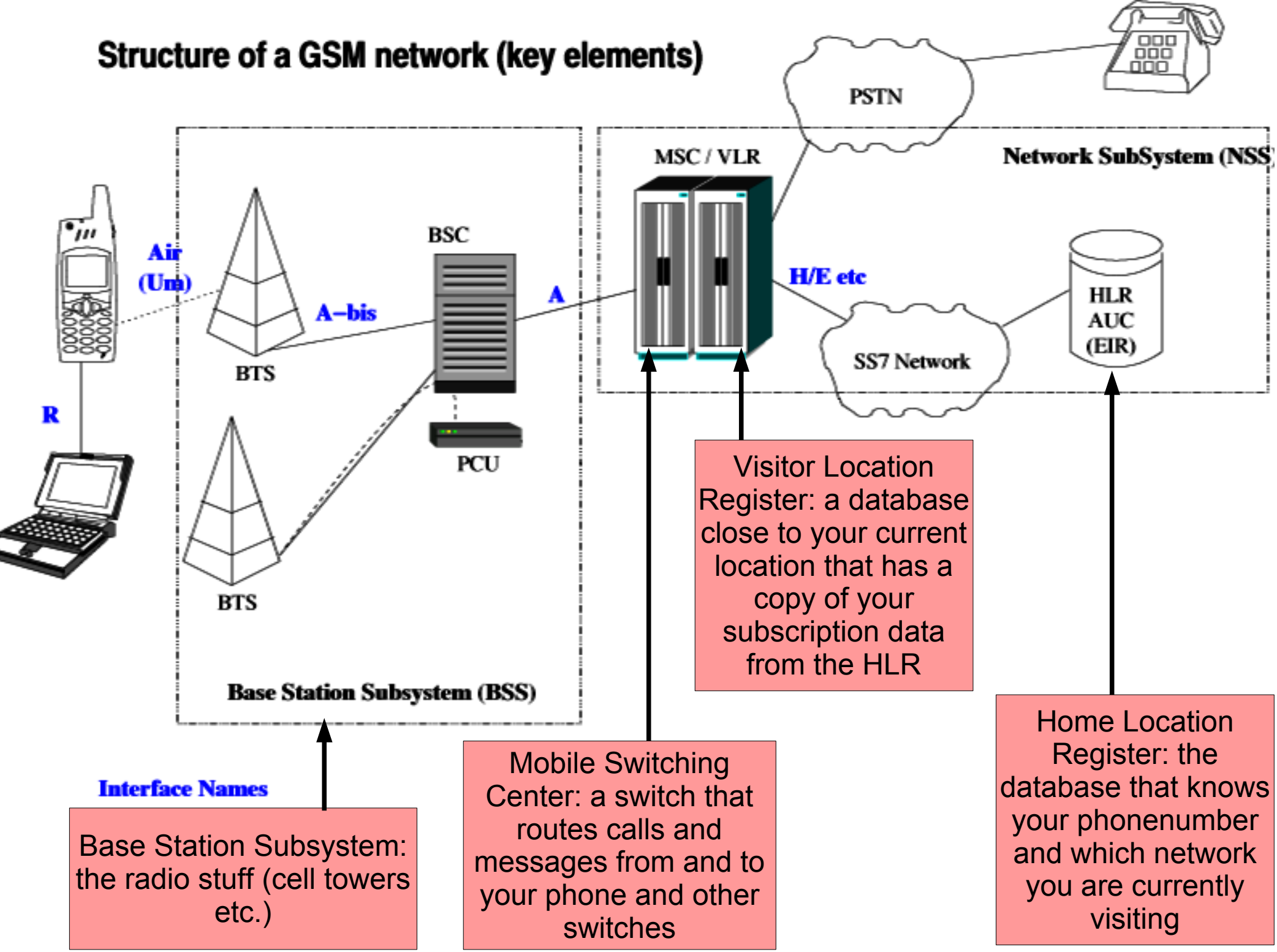
What is Signalling System #7?

- protocol suite used by most telecommunications operators throughout the world to talk to each other
- standardized in ITU-T Q.700 series
- when it was designed, there were only few telecoms operators, and they were either state controlled or really big corporations
- trusted each other, so no authentication built in
- today, everybody can be an operator (e.g. VoIP), so SS7 access is easier to get

Mobile Application Part (MAP)

- part of SS7 that specifies additional signalling that is required for mobile phones to work (roaming, SMS, etc.)
- standardized in 3GPP TS 29.002
- in order for two network operators to talk MAP to each other they usually need a roaming agreement


Structure of a GSM network (key elements)
PSTN
MSC / VLR
Network SubSystem (NSS)
Air
(Um)
BSC
A
A–bis
H/E etc
HLR
AUC
(EIR)
SS7 Network
BTS
BTS
PCU
R
Base Station Subsystem (BSS)
Interface Names
Base Station Subsystem: the radio stuff (cell towers etc.)
Mobile Switching Center: a switch that routes calls and messages from and to your phone and other switches
Visitor Location Register: a database close to your current location that has a copy of your subscription data from the HLR
Home Location Register: the database that knows your phonenumber and which network you are currently visiting

What does the network know about your location?

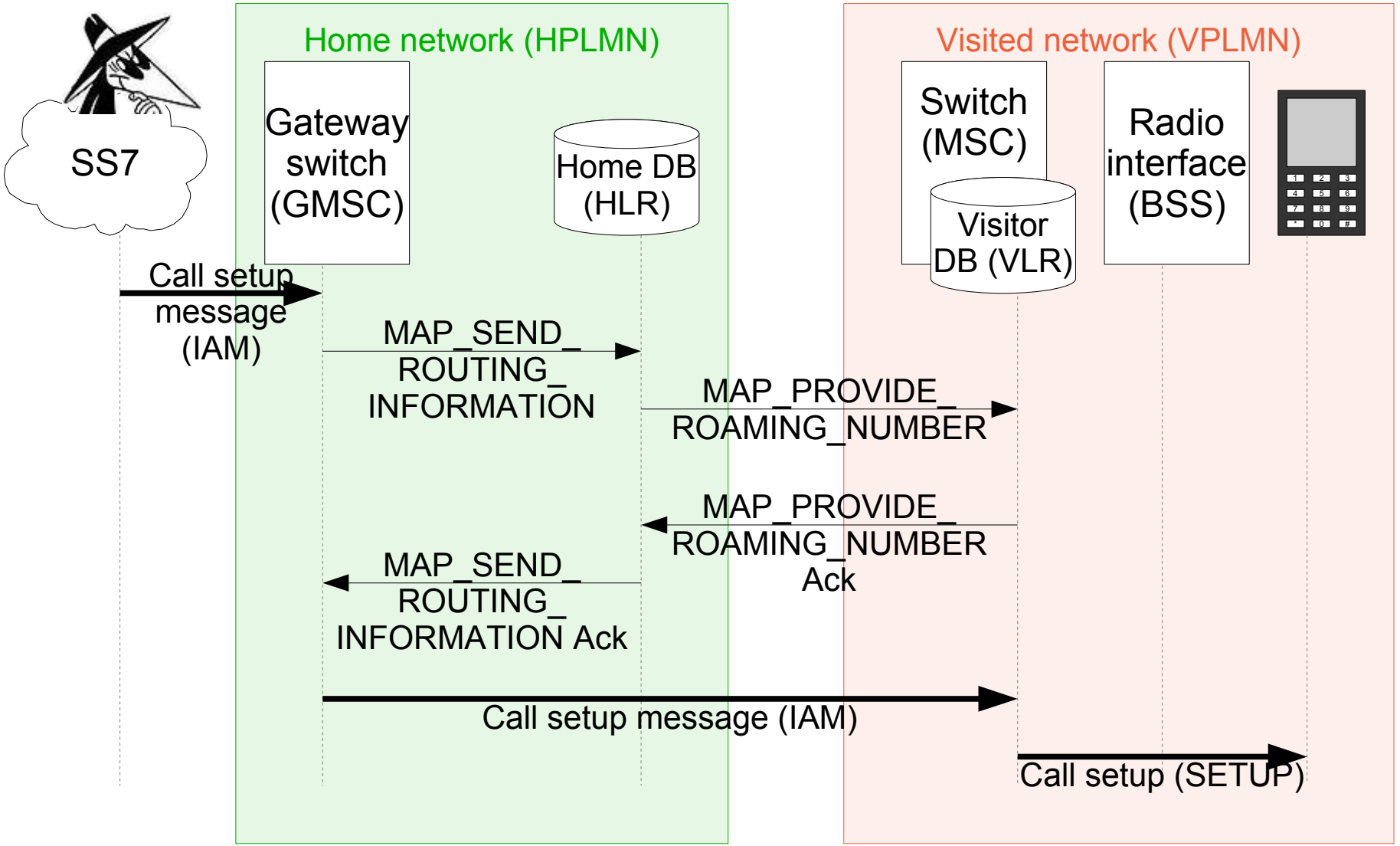
- the location of the cell tower is also a pretty good approximation of *your* location
- but that information is only known to the network you are currently logged into
- restricted to technical operation of the network - exceptions:
  - "Locate my phone" services
    - have to assure the operator that they have the consent of the phone's owner
    - doesn't work anymore as soon as you are logged into a network that is not your home network
  - Law enforcement
    - have to call the operator of the network you are currently logged into (*not* your home network operator)

Can somebody with SS7/MAP access find out your location?

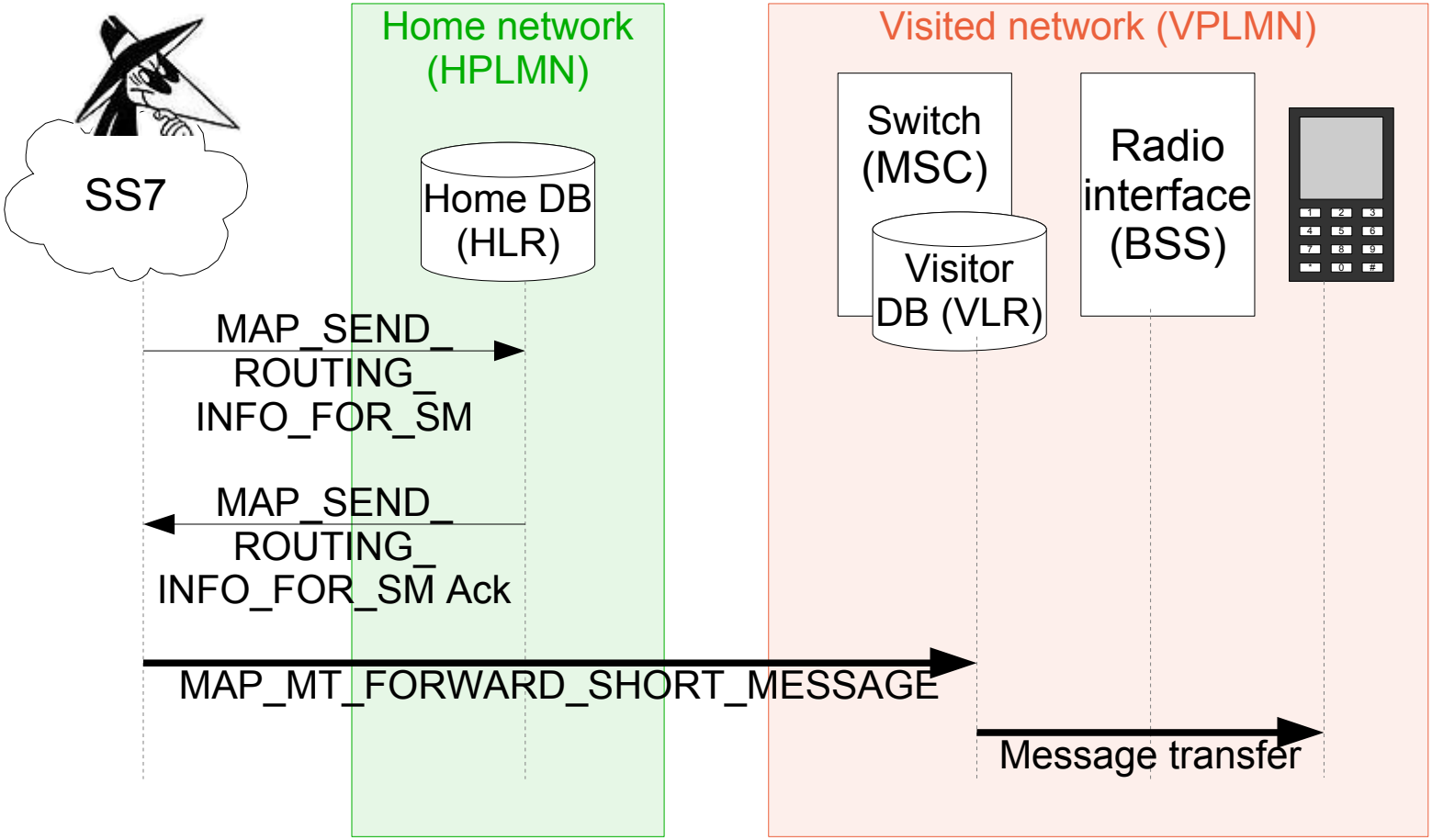
- services that can be initiated to your phone number from almost anywhere in the global SS7 network are
  - voice calls
  - short messages

Let's see if these services give any indication of your location...

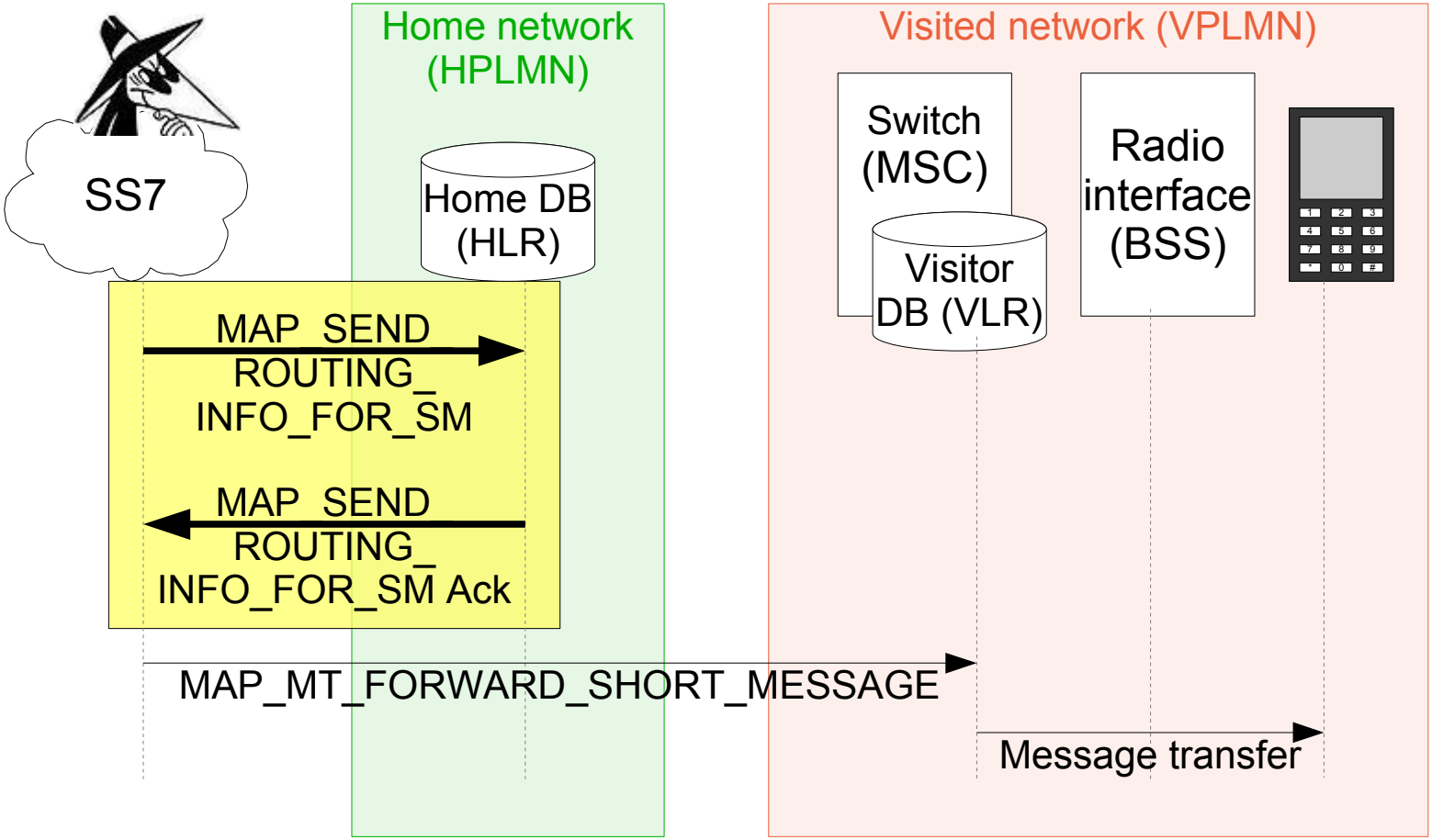
Call setup


SS7
Home network (HPLMN)
Gateway switch (GMSC)
Home DB (HLR)
Visited network (VPLMN)
Switch (MSC)
Visitor DB (VLR)
Radio interface (BSS)
Call setup message (IAM)
MAP_SEND_ ROUTING_ INFORMATION
MAP_PROVIDE_ ROAMING_NUMBER
MAP_PROVIDE_ ROAMING_NUMBER Ack
MAP_SEND_ ROUTING_ INFORMATION Ack
Call setup message (IAM)
Call setup (SETUP)

Sending a short message



Sending a short message



MAP-SEND-ROUTING-INFO-FOR-SM (3GPP TS 29.002)

- no correlation between requesting routing info for a message and actually sending a message
- SMS are sent directly from the SMSC of the sender to the MSC that you are currently using

- successful request returns:
  - your IMSI ("real" phone number)
  - global title of MSC you are using
  - user error (e.g. "Absent subscriber" == your phone is off)

Mobile Switching Center (MSC)

- handles calls and SMS
- can only handle a certain amount of calls, so in big cities there might be more than one MSC for each network, while in the countryside one MSC might serve a really large area
- global title of the MSC tells us which country you are currently in, because it starts with the country code
- maybe also the network, if mobile networks in that country can be identified by their area code
- other than that: numbering is operator internal

  ... but that doesn't mean that we cannot get further information from the number by looking at it long enough

MSC global title (examples)

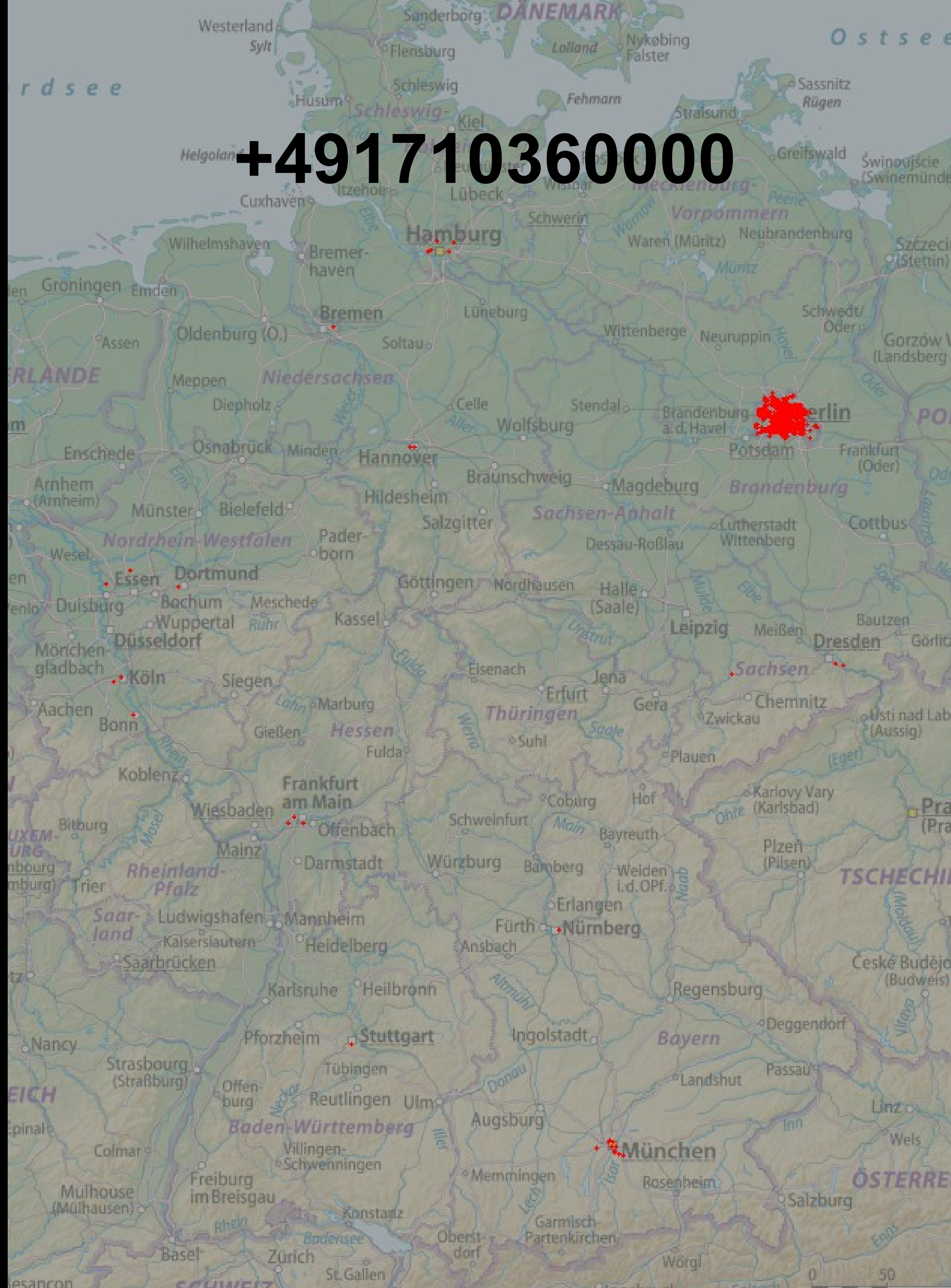
	T-Mobile Germany	Vodafone Germany
Berlin	+491710360000	+491720012097
Hamburg	+491710400000	+491720022097
Frankfurt	+491710650000	+491720061097
Stuttgart	+491710700000	+491720076097
München	+491710870000	+491720082097

MSC global title (examples)

	T-Mobile Germany	Vodafone Germany
	First digit of area code	First digit of ZIP code
Berlin	+4917103600**0**0	+4917200**1**2097
Hamburg	+4917104000**0**0	+4917200**2**2097
Frankfurt	+4917106500**0**0	+4917200**6**1097
Stuttgart	+4917107000**0**0	+4917200**7**6097
München	+4917108700**0**0	+4917200**8**2097

Automated approach to narrow down the area an MSC is serving (1/2)

- Rop had a great idea: if we have a lot of mobile phone numbers and already know their location, we could query the network for the current MSC of these numbers, thus creating a MSC ↔ geolocation mapping
- thanks to erdgeist, we have a decoded copy of the "Das Telefonbuch" CD
- sent tens of thousands of MAP_SEND_ROUTING_INFO_FOR_SM requests for numbers from the phonebook
  - requests where done at night, when most people are at home
  - removed the obvious errors



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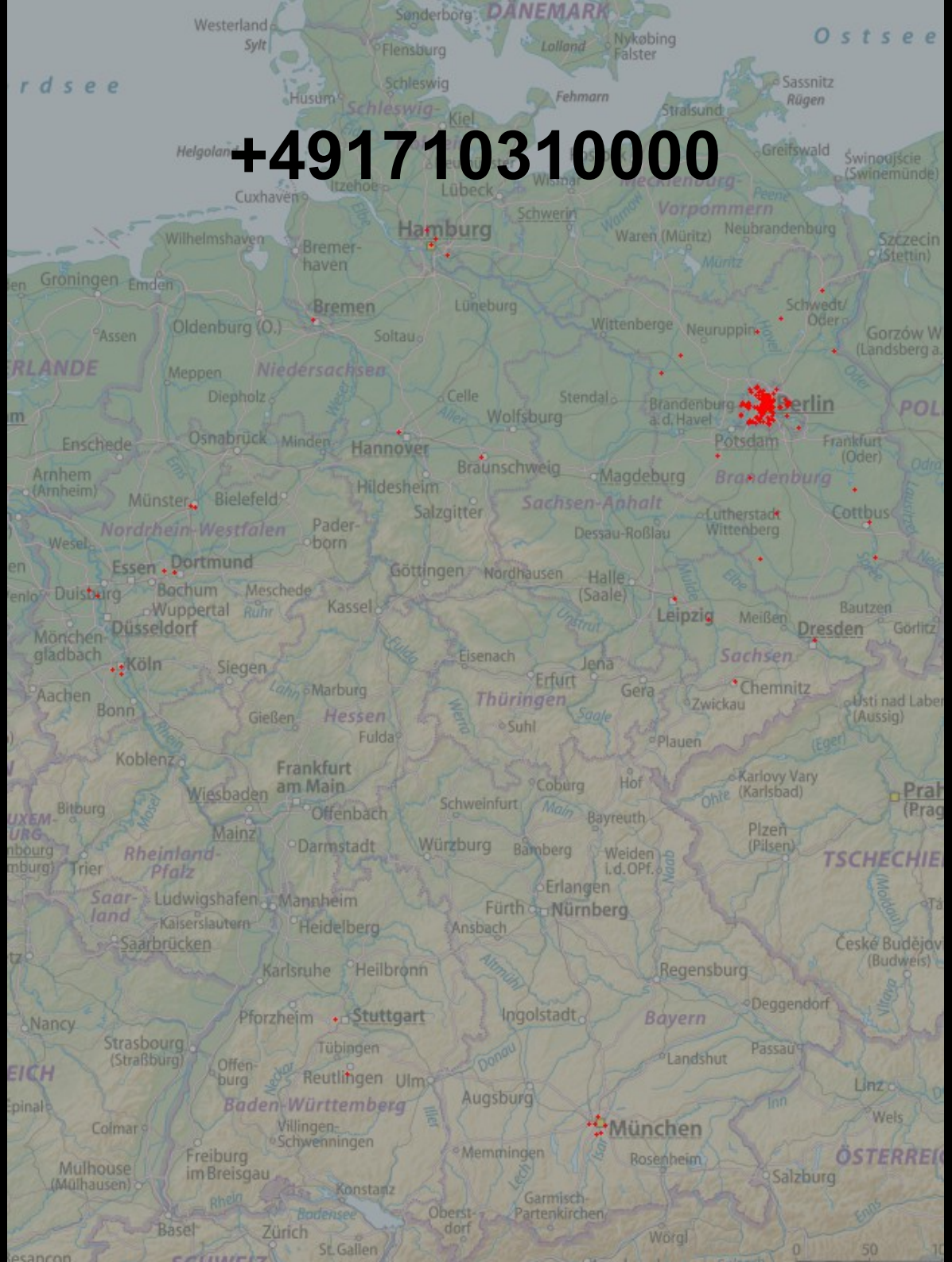
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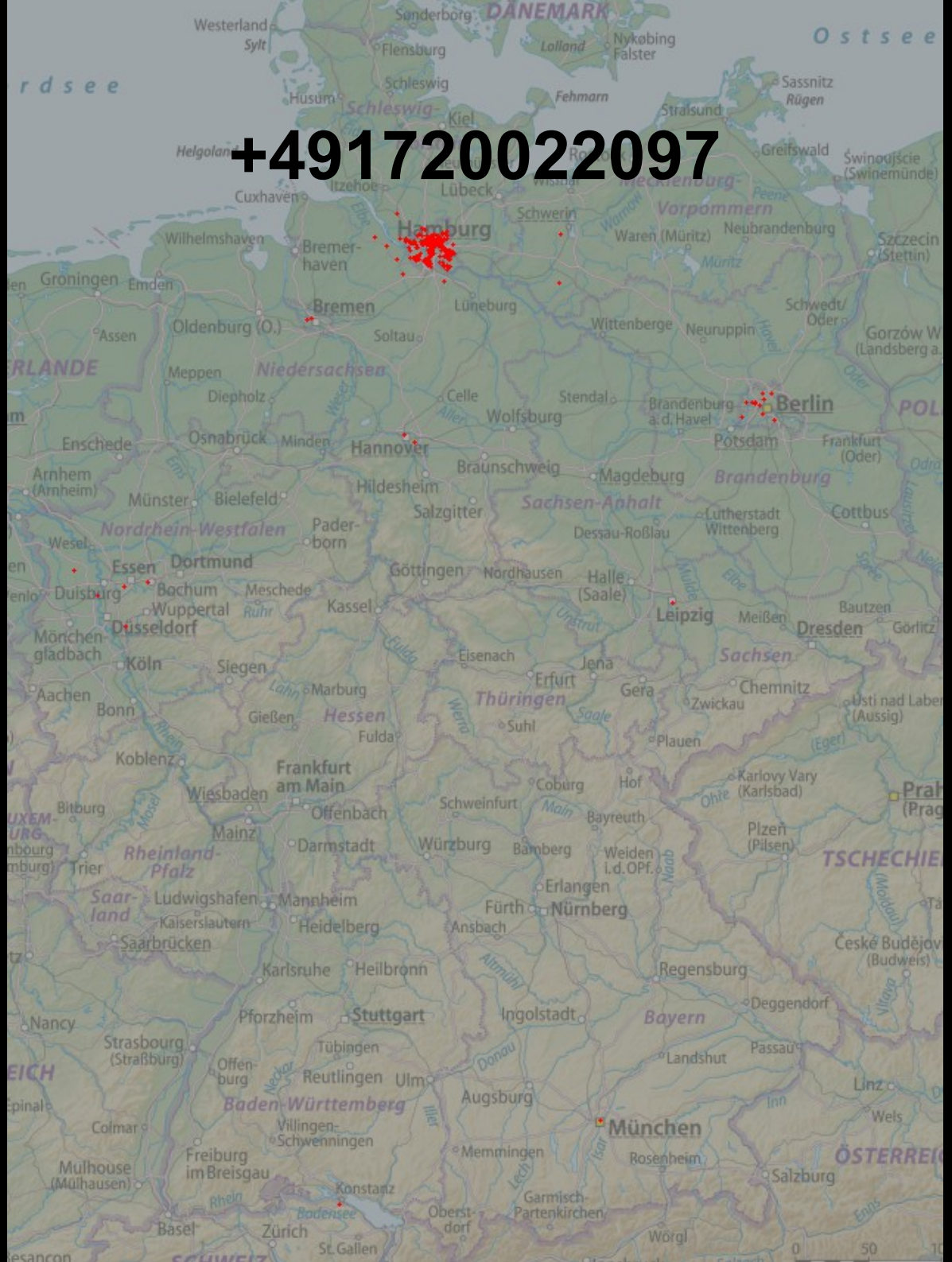
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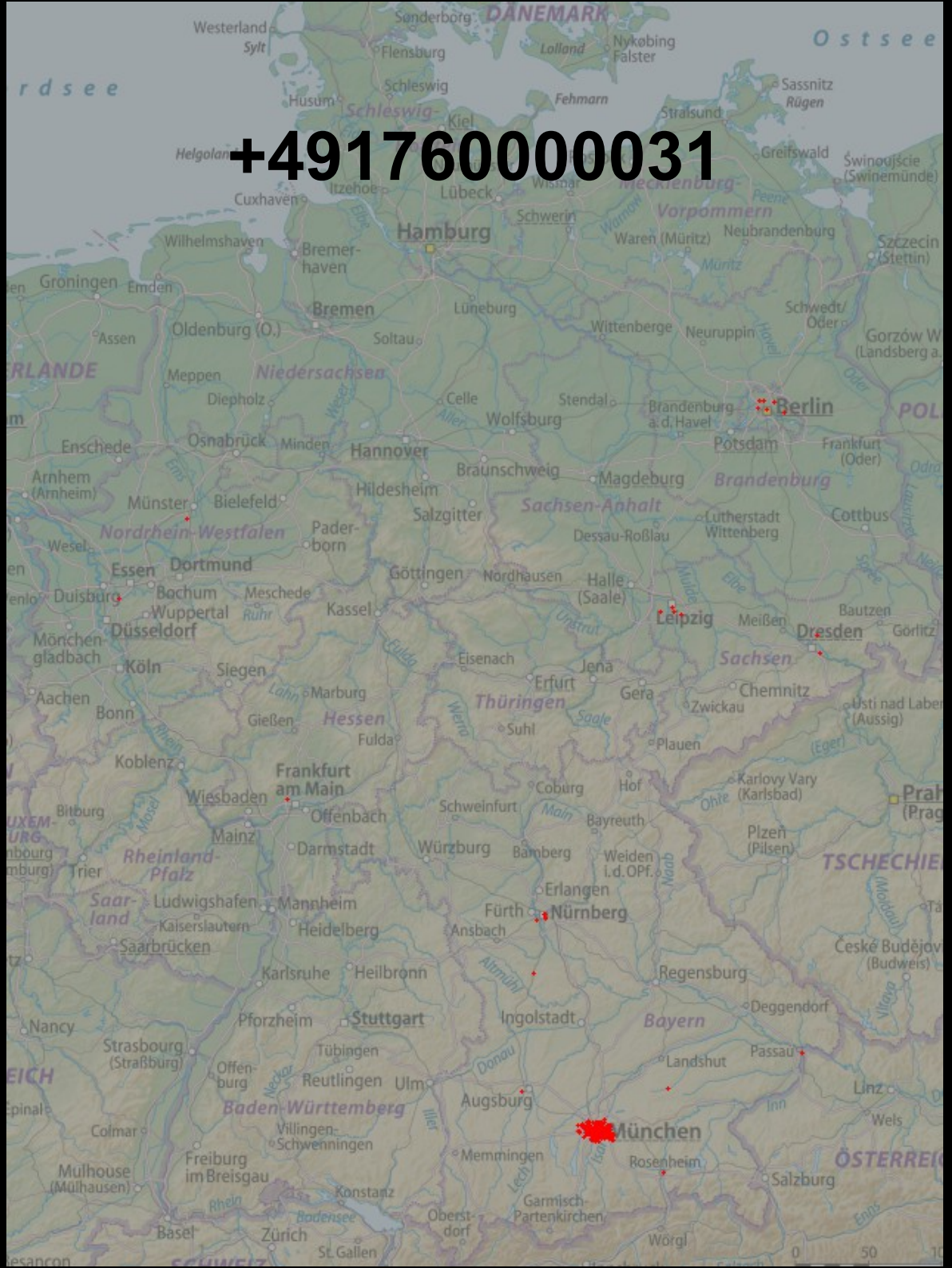
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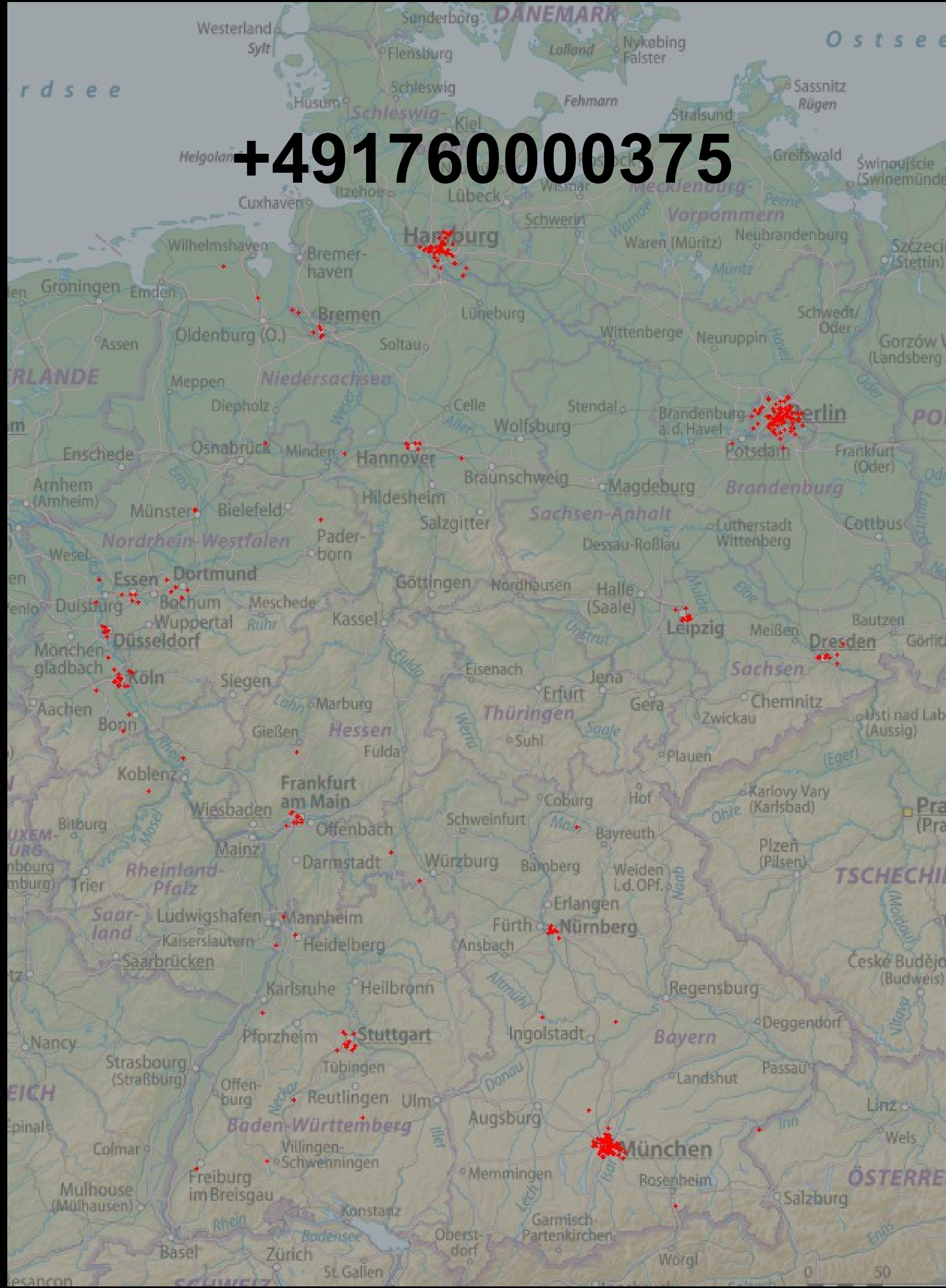
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St. Gallen
Besançon
SCHWEIZ

Automated approach to narrow down the area an MSC is serving (2/2)

- big thanks to itsme, who created such a mapping for the Netherlands

- other countries also possible if there are phone books available

"No one I know is a network operator - so I can be pretty sure that no one who would care finds out my location, right?"

- wrong: there are several companies offering a lookup service where you send them an MSISDN, they perform a MAP-SEND-ROUTING-INFO-FOR-SM request and send the IMSI and MSC they receive from the HLR back to you

- cost per request is in the low single euro cent area

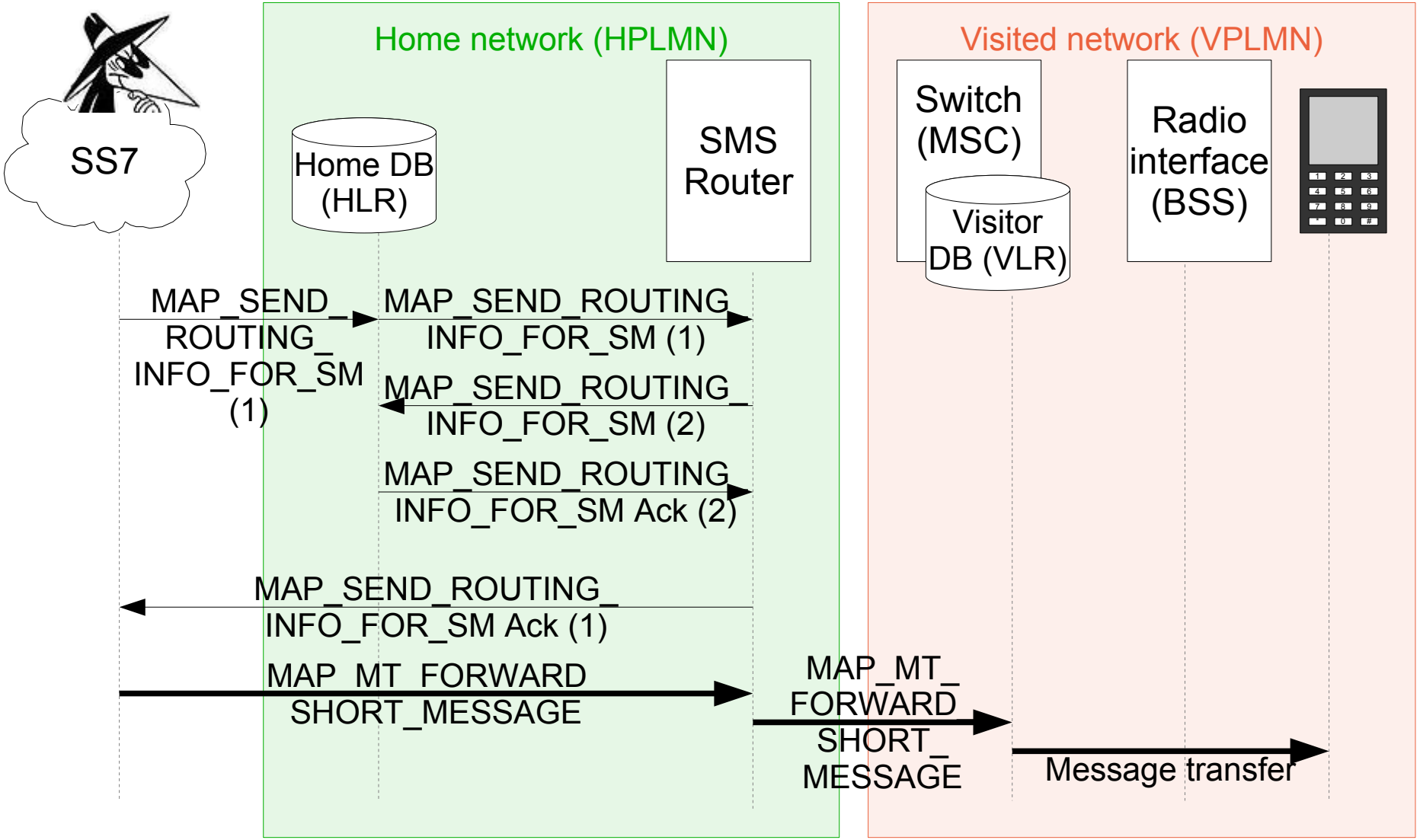
What is the business case for selling this service?

- Evil_Spammer wants to send spam SMS without paying
- he has SS7 access, and can also send MAP requests, but of course he has no roaming agreements with any other operators, so they don't answer his requests
- but: sending a message via MAP_MT_FORWARD_SHORT_MESSAGE does not even require an answer!
- Evil_Spammer just needs to know, to which MSC the message should be sent, so he uses one of these services...
- then he sets the sender address of the SMS request to that of another networks short message center
- the receiving network bills the SMS to that other network → free spam SMS!

I don't want to be located - what can I do? (1/2)

- SMS "home routing" (3GPP TR 23.840) will fix the problem
  - all messages to your phone are routed to an SMS router in your home network
  - that router will then deliver the message to your phone
  - MAP-SEND-ROUTING-INFO-FOR-SM only returns the ISDN number of the SMS router
  - instead of the IMSI, a random "correlation id" will be returned
  - operators will implement this to
    - prevent fraud
    - enable "VAS"
    - enable "lawful interception" of SMS sent to you when you are in another country

SMS "home routing" (3GPP TR 23.840)



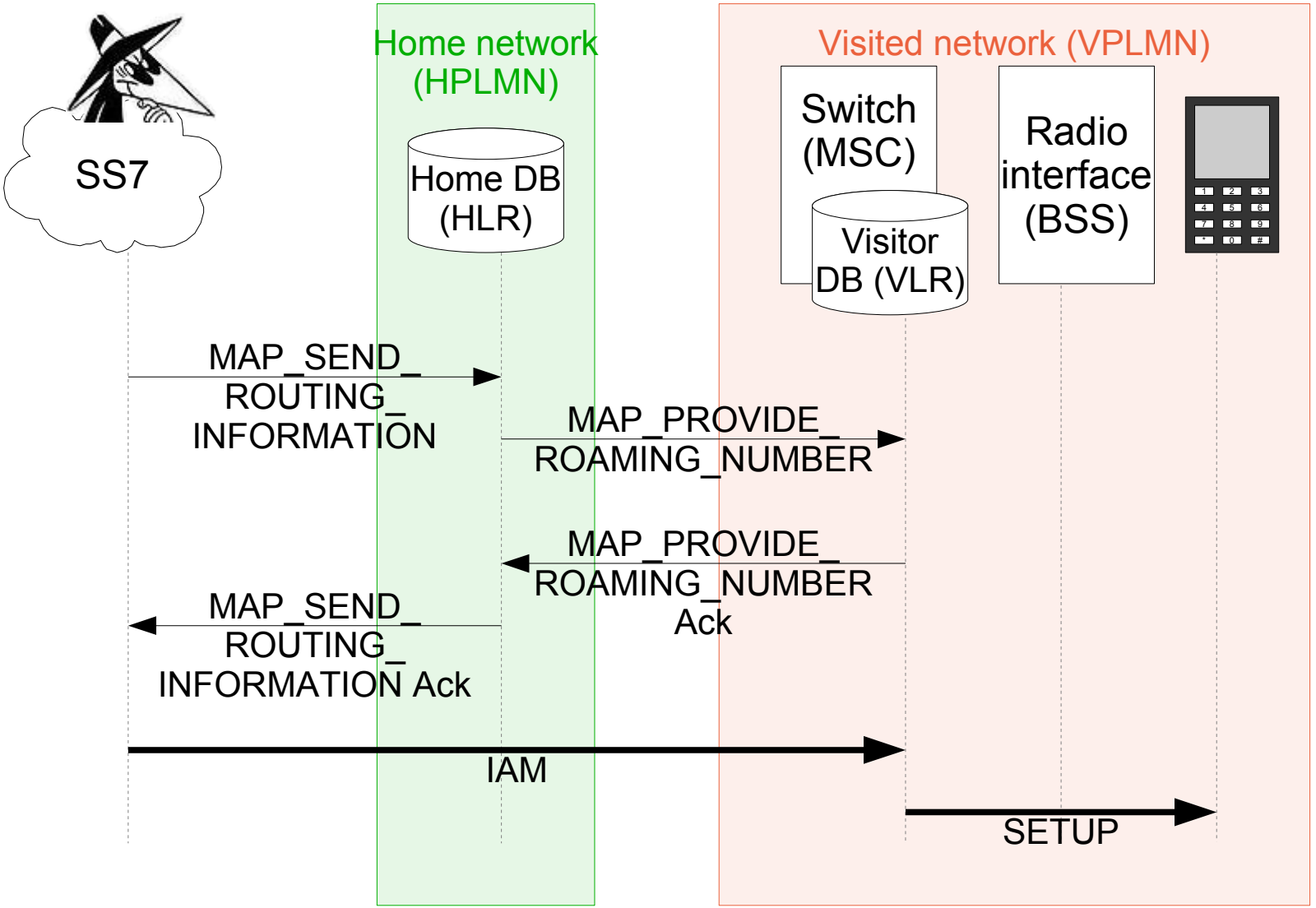
I don't want to be located - what can I do? (2/2)

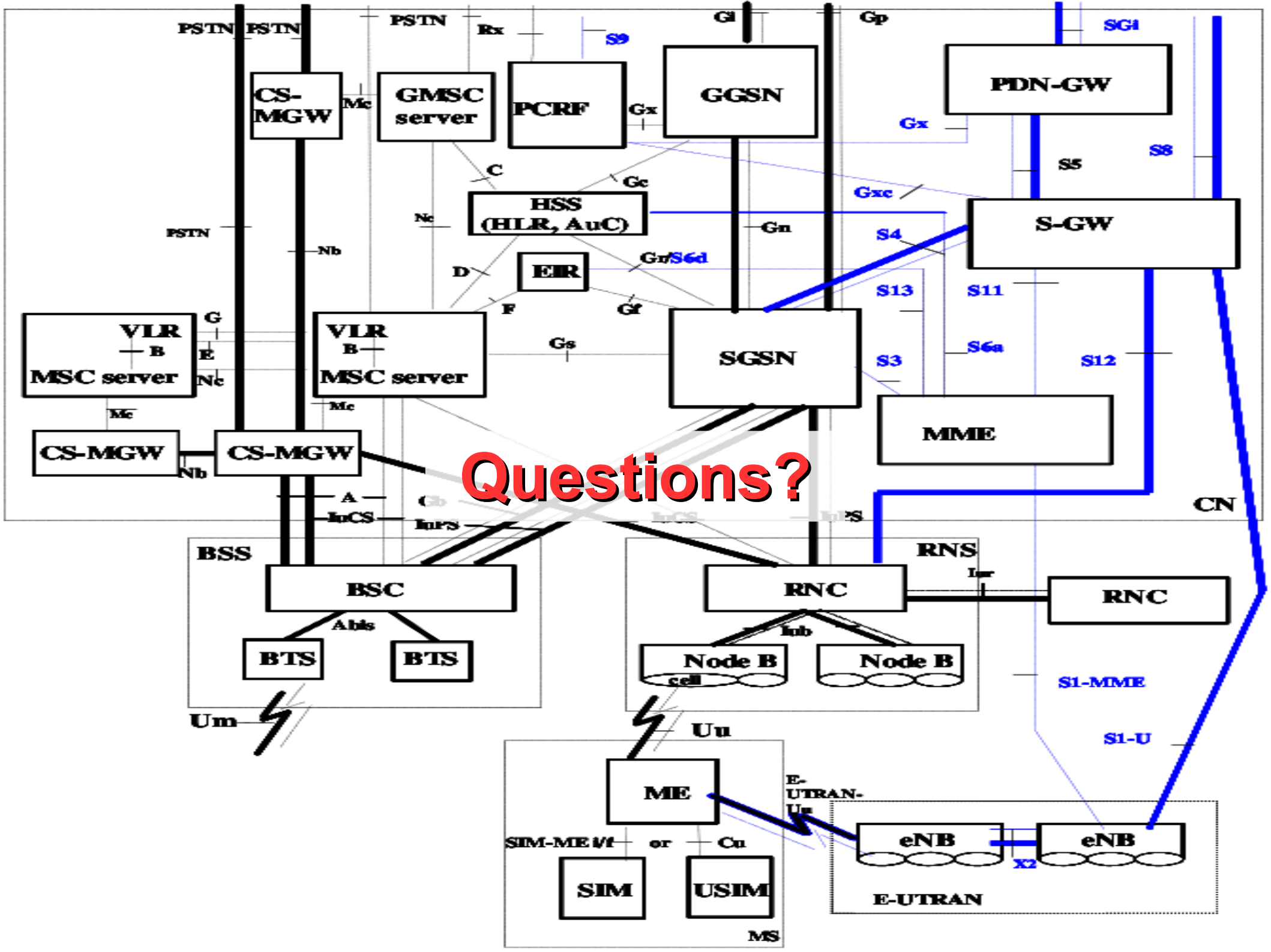
- until home routing is in use:
  - some networks offer multiple SIMs for one phone number and use an SMS router to decide which SIM will receive the SMS (e.g. o2 Germany)
  - let your operator block incoming SMS for your phone number
  - switch your phone off

What's next: Optimal routeing

- Specified in 3GPP TS 23.079
- makes it possible to route calls directly to the network you are currently logged into
- this can only work if the entity that sets up the call has a way of finding out, which MSC you are currently using...
- OR is currently not widely in use
- charging issues have to be worked out

Call setup with Optimal Routeing

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