COSEINC®
Solid Security.Verified.

Base Jumping

Attacking the GSM baseband and base station

grugq@coseinc.com

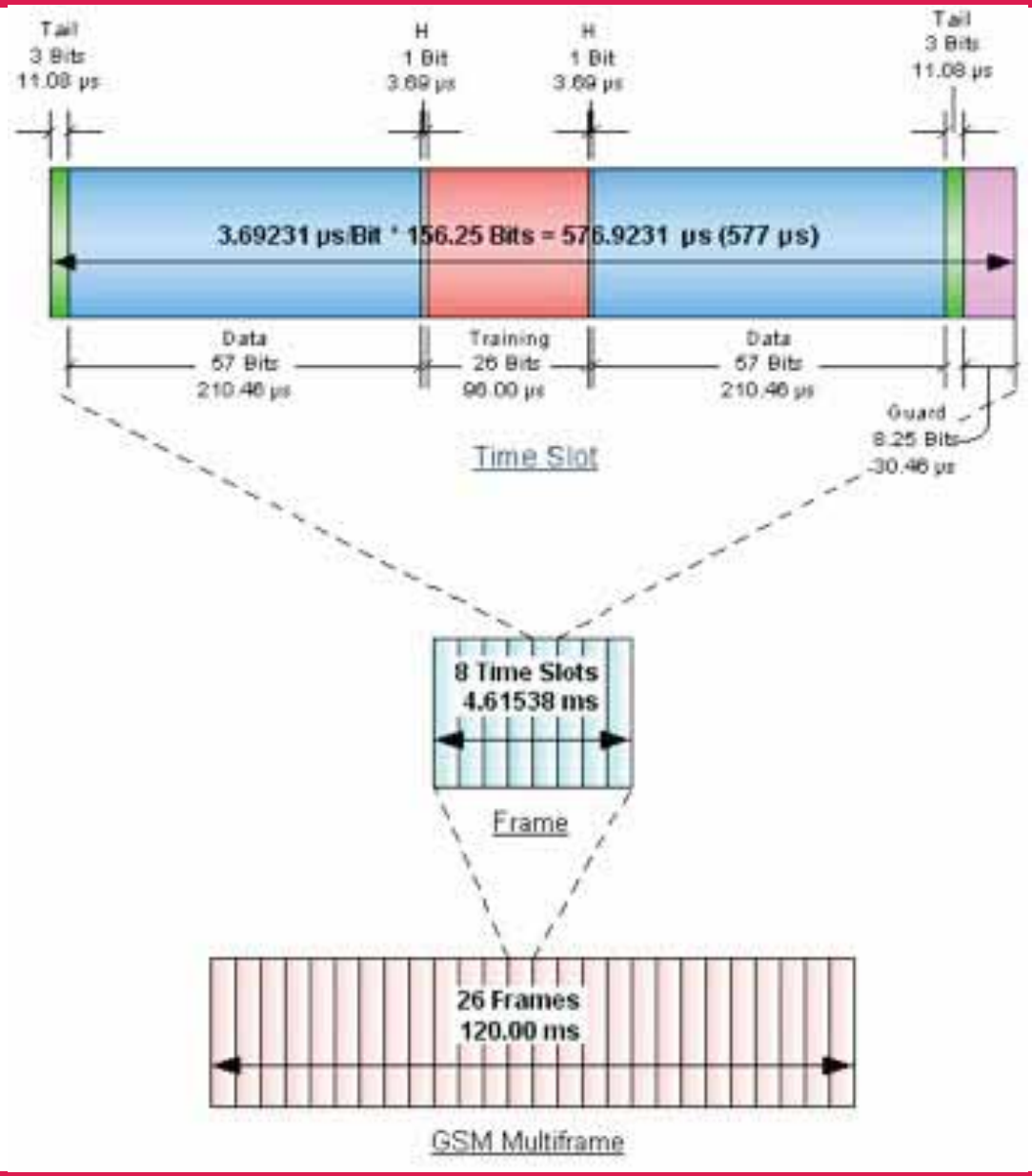
Overview

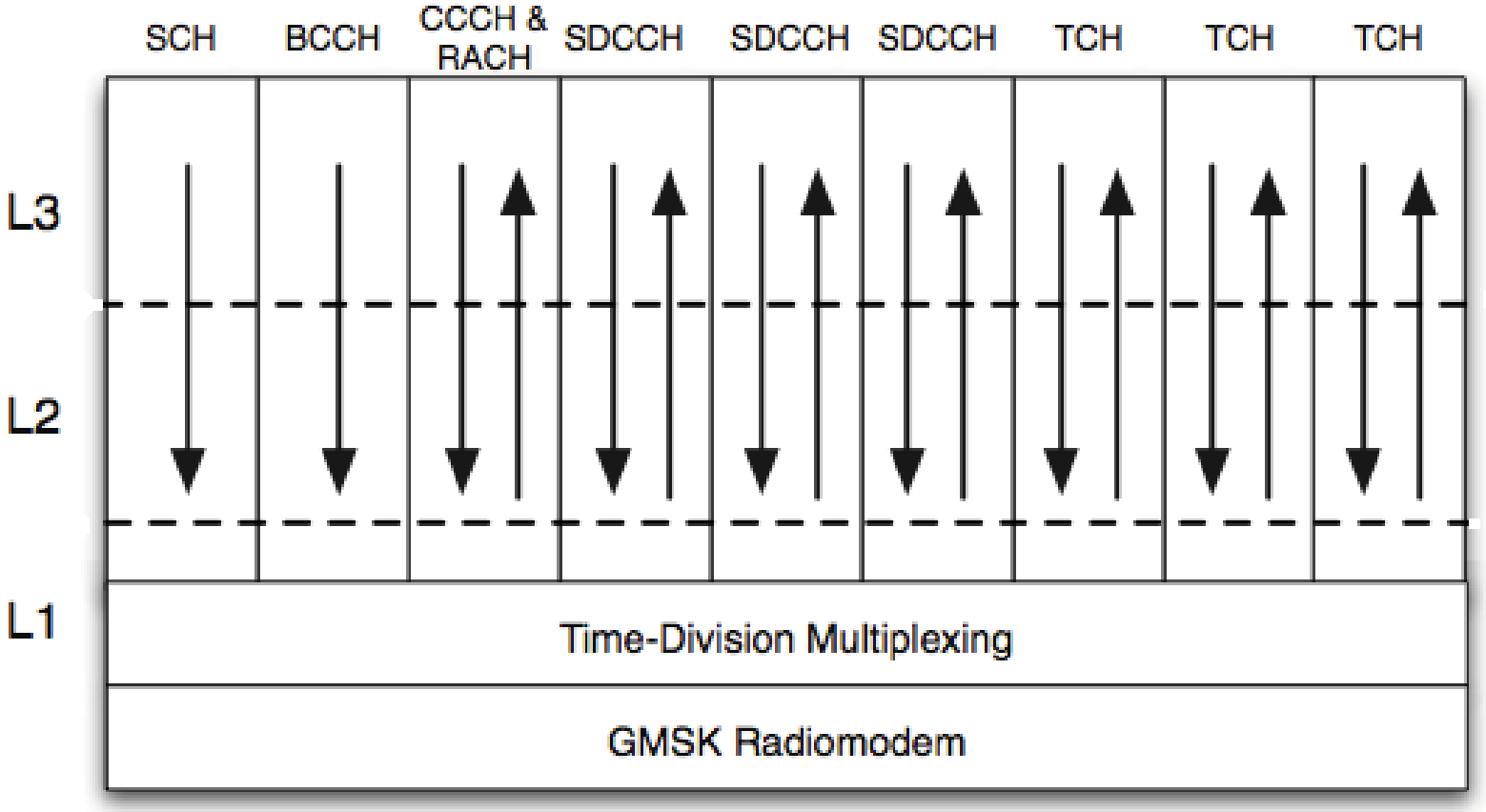
- GSM
- Base Station
- Base Band
- Conclusion

GSM: The Protocol

Documents

- Dozens of docs
- Thousands of pages
- Important one (defines L3)
  - GSM 04 08


Tail
3 Bits
11.08 µs
H
1 Bit
3.69 µs
H
1 Bit
3.69 µs
Tail
3 Bits
11.08 µs
3.69231 µs/Bit * 156.25 Bits = 576.9231 µs (577 µs)
Data
57 Bits
210.46 µs
Training
26 Bits
96.00 µs
Data
57 Bits
210.46 µs
Guard
8.25 Bits
30.46 µs
Time Slot
8 Time Slots
4.61538 ms
Frame
26 Frames
120.00 ms
GSM Multiframe


SCH
BCCH
CCCH & RACH
SDCCH
SDCCH
SDCCH
TCH
TCH
TCH
L3
L2
L1
Time-Division Multiplexing
GMSK Radiomodem

Logical Channels

Broadcast Channels (BCH)

- Broadcast Control Channel (BCCH)
- Frequency Correction Channel (FCCH)
- Synchronization Channel (SCH)
- Cell Broadcast Channel (CBCH)

Logical Channels, cont.

- **Common Control Channels (CCCH)**
  - Paging Channel (PCH)
  - Random Access Channel (RACH)
  - Access Grant Channel (AGCH)

Logical Channels, cont.

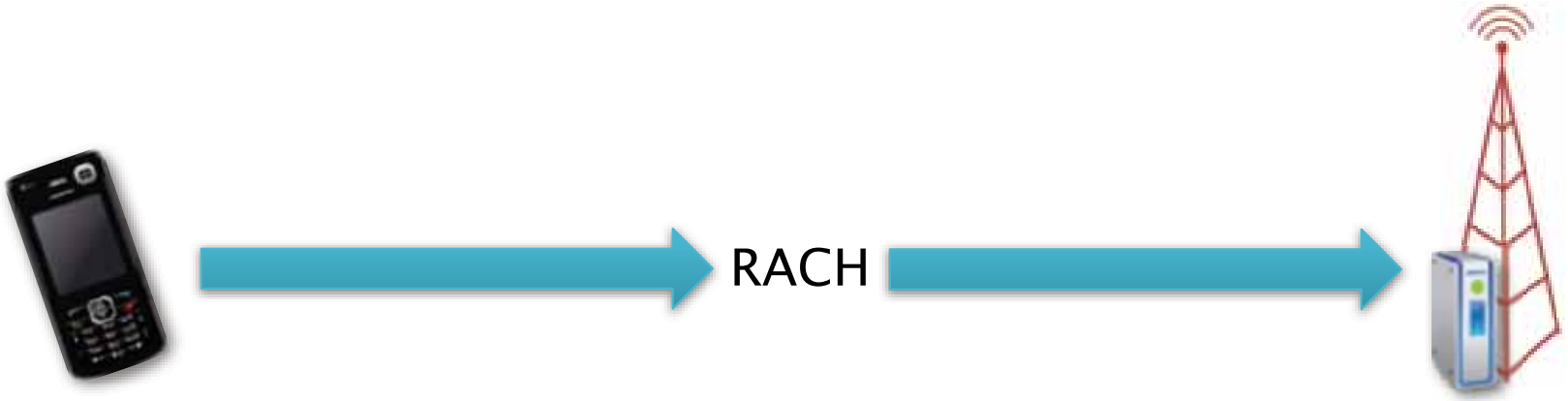
Standalone Dedicated Control Channel (SDCCH)

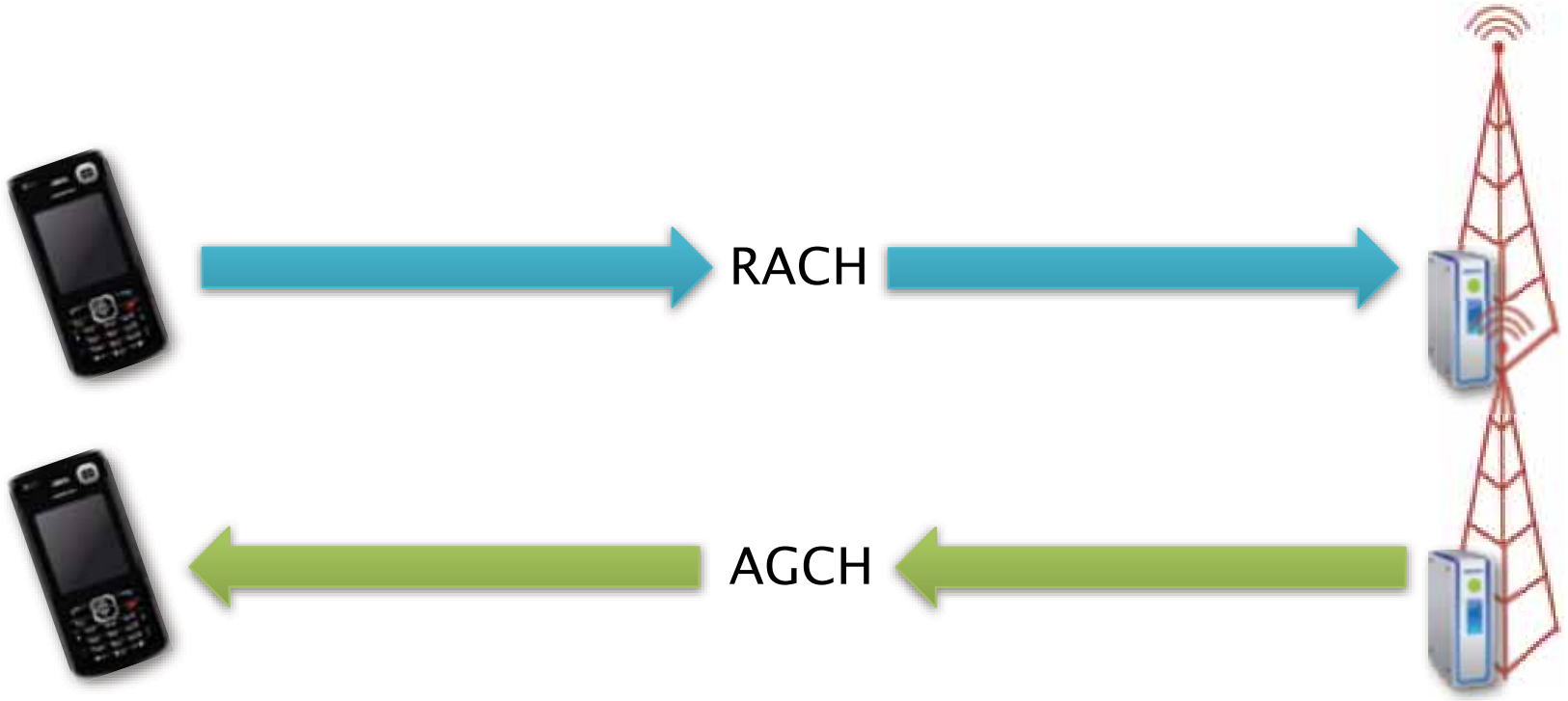
- Associated Control Channel (ACCH)
- Fast Associated Control Channel (FACCH)
- Slow Associated Control Channel (SACCH)

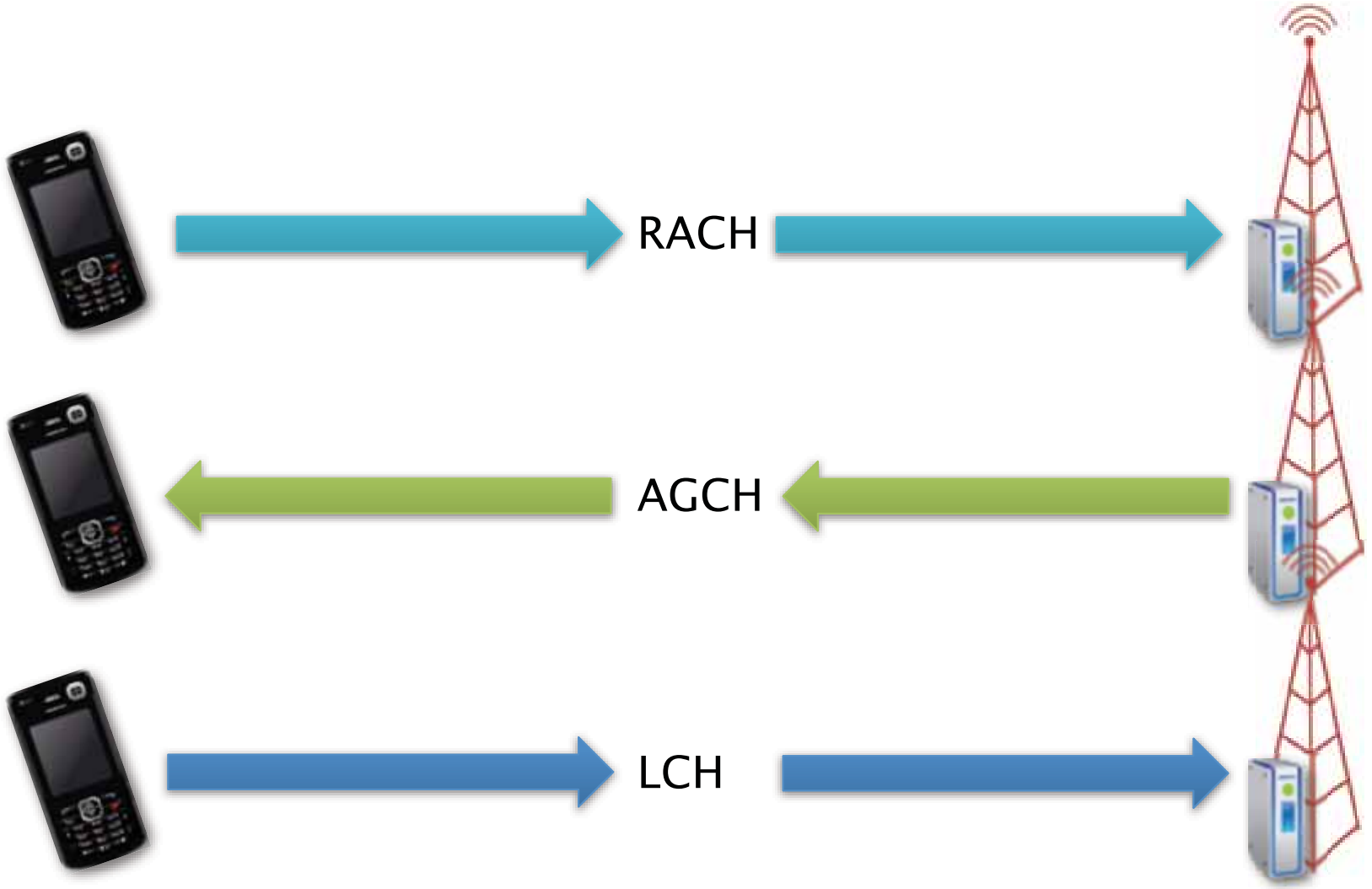
GSM Channels

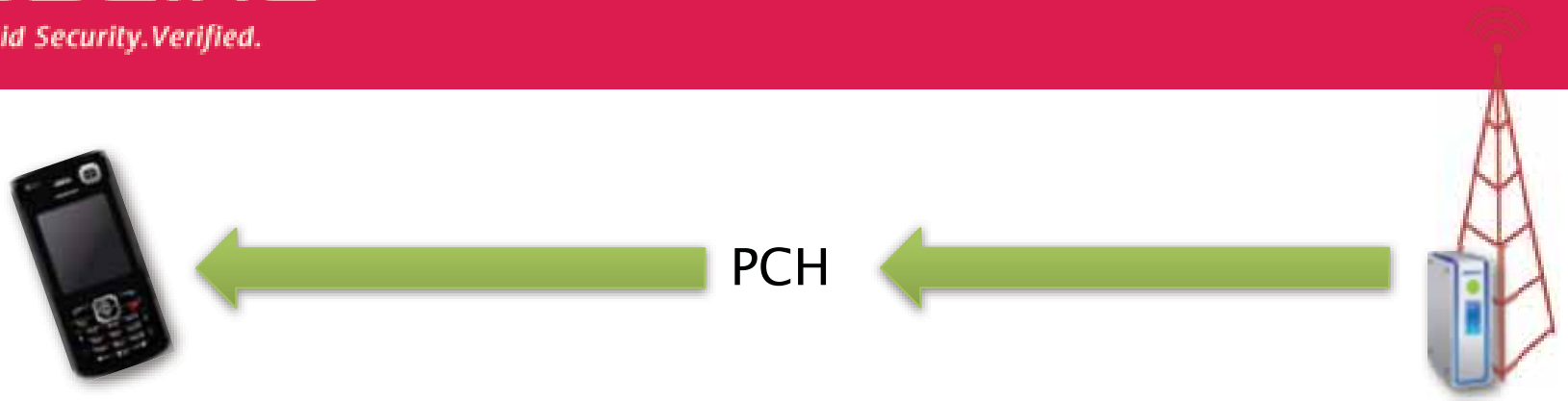
- Opening a channel is slow
  - Can take seconds
- Specific channels for specific uses

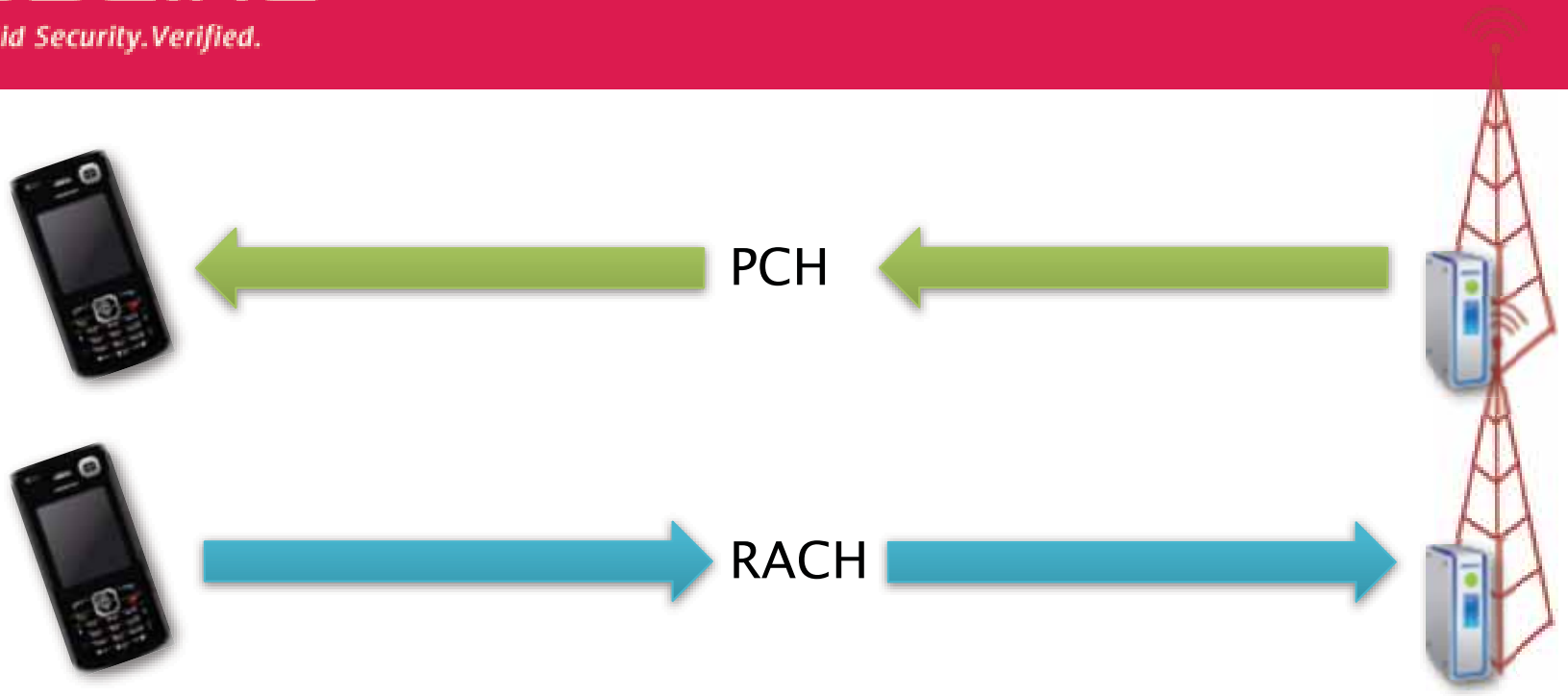
Opening a channel

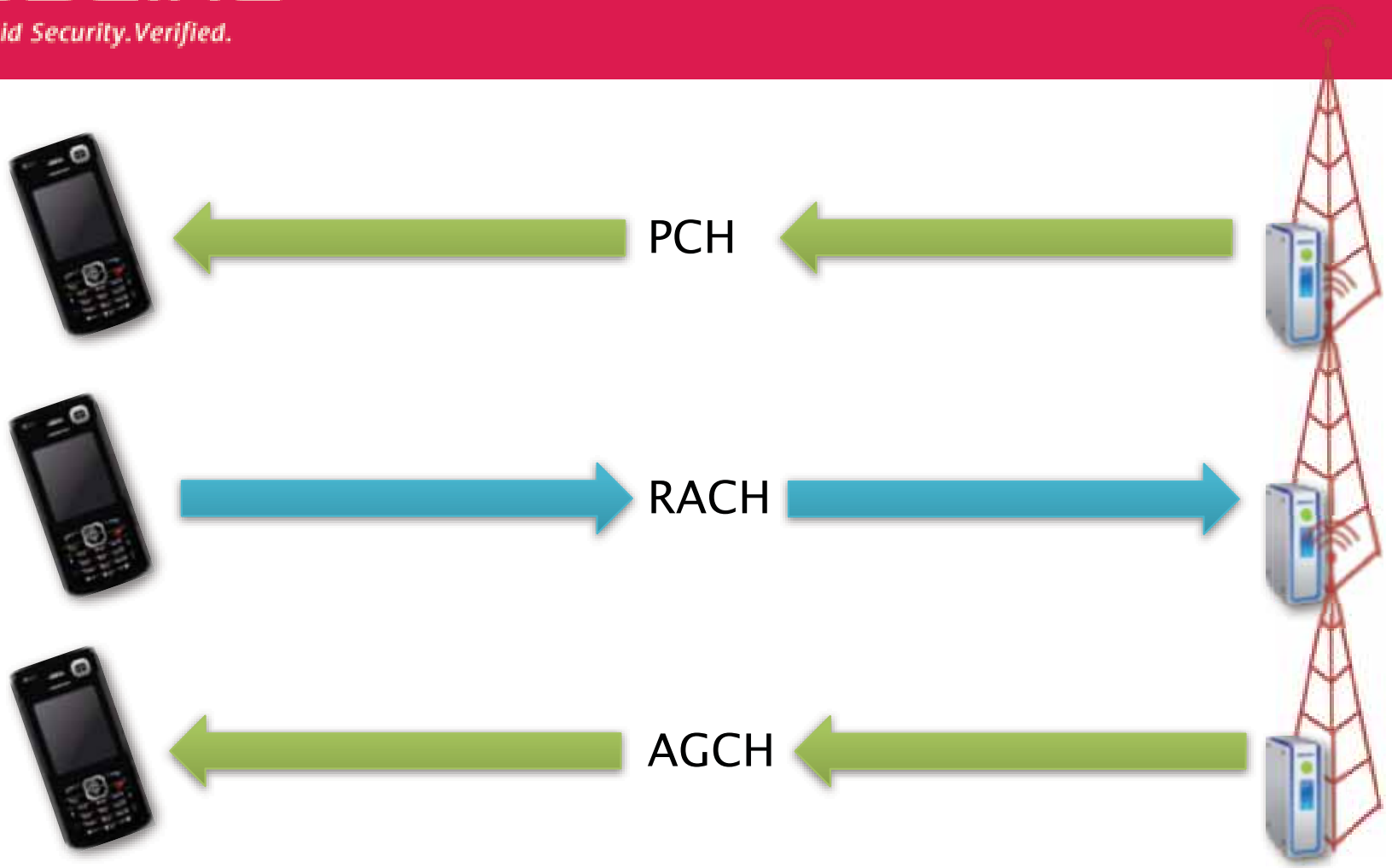

RACH

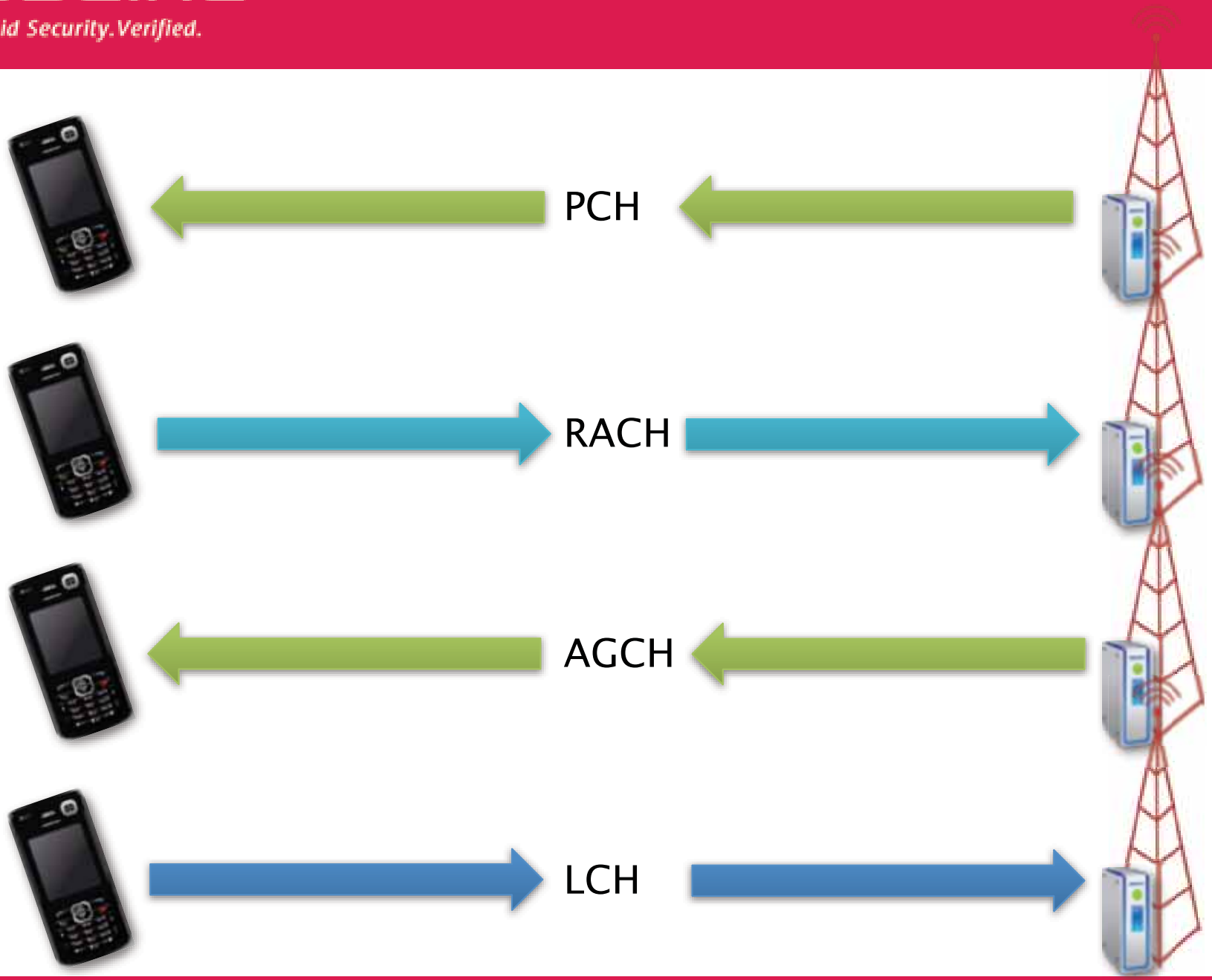

RACH
AGCH

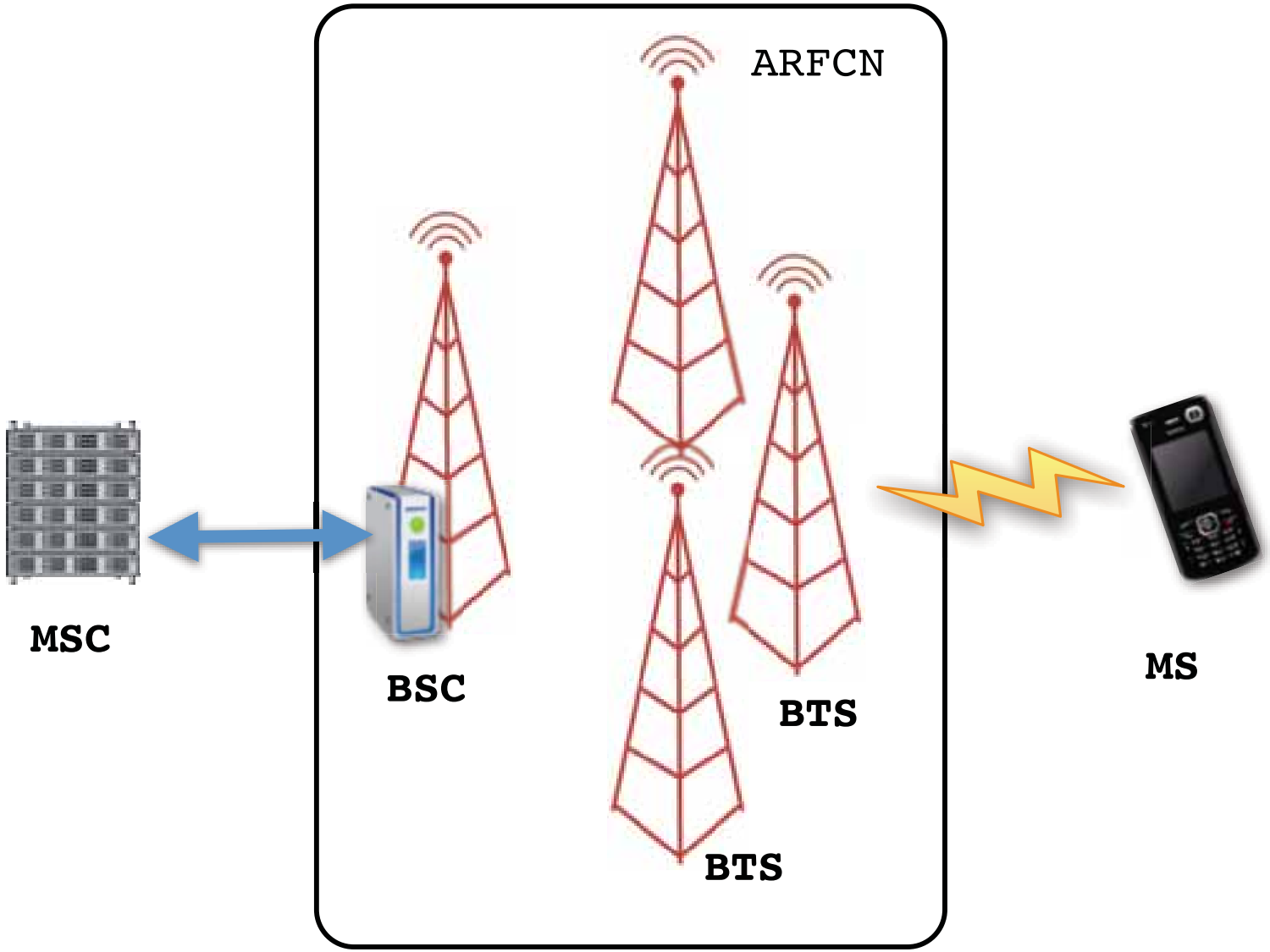

RACH
AGCH
LCH

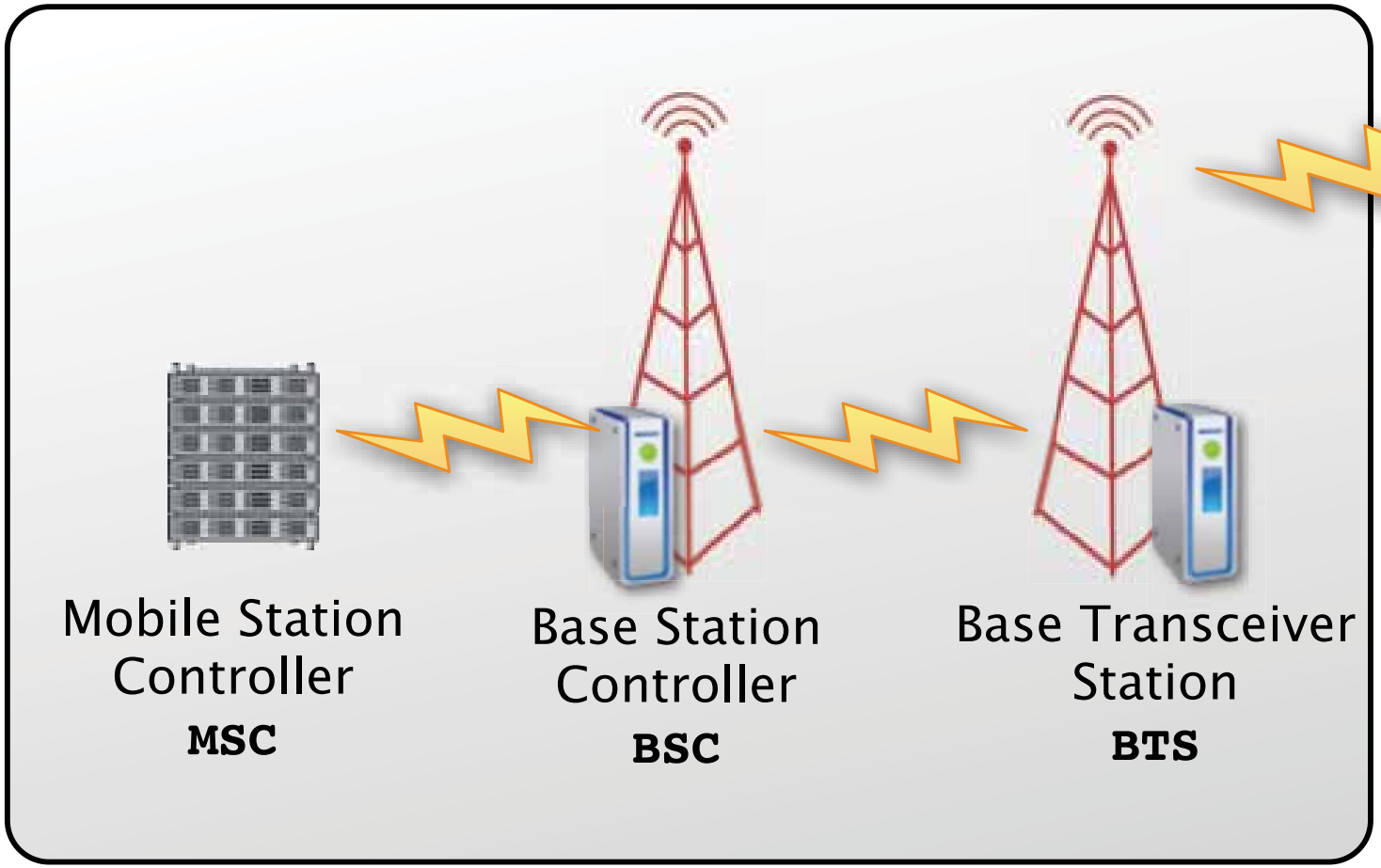

PCH

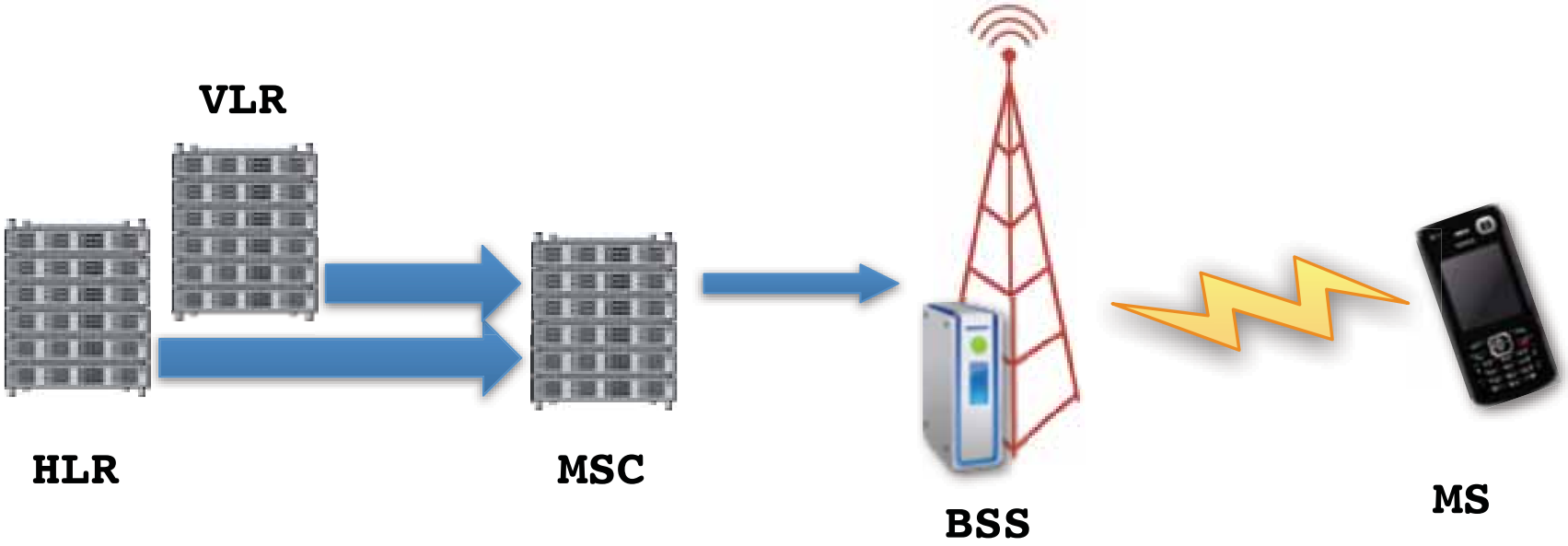

PCH
RACH


PCH
RACH
AGCH


PCH
RACH
AGCH
LCH


ARFCN
MSC
BSC
BTS
BTS
MS

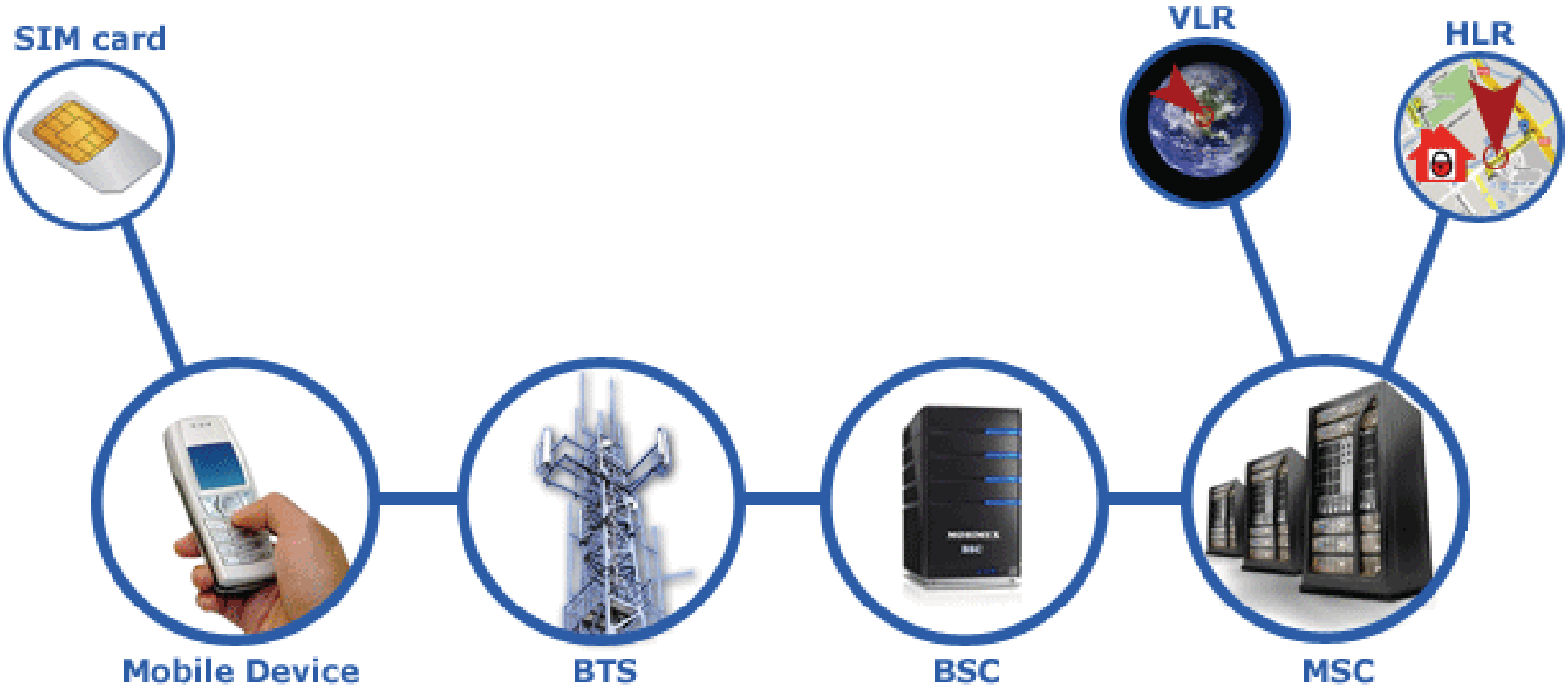

Mobile Station Controller
MSC
Base Station Controller
BSC
Base Transceiver Station
BTS
Mobile Station
MS
Base Station Sub-System
BSS

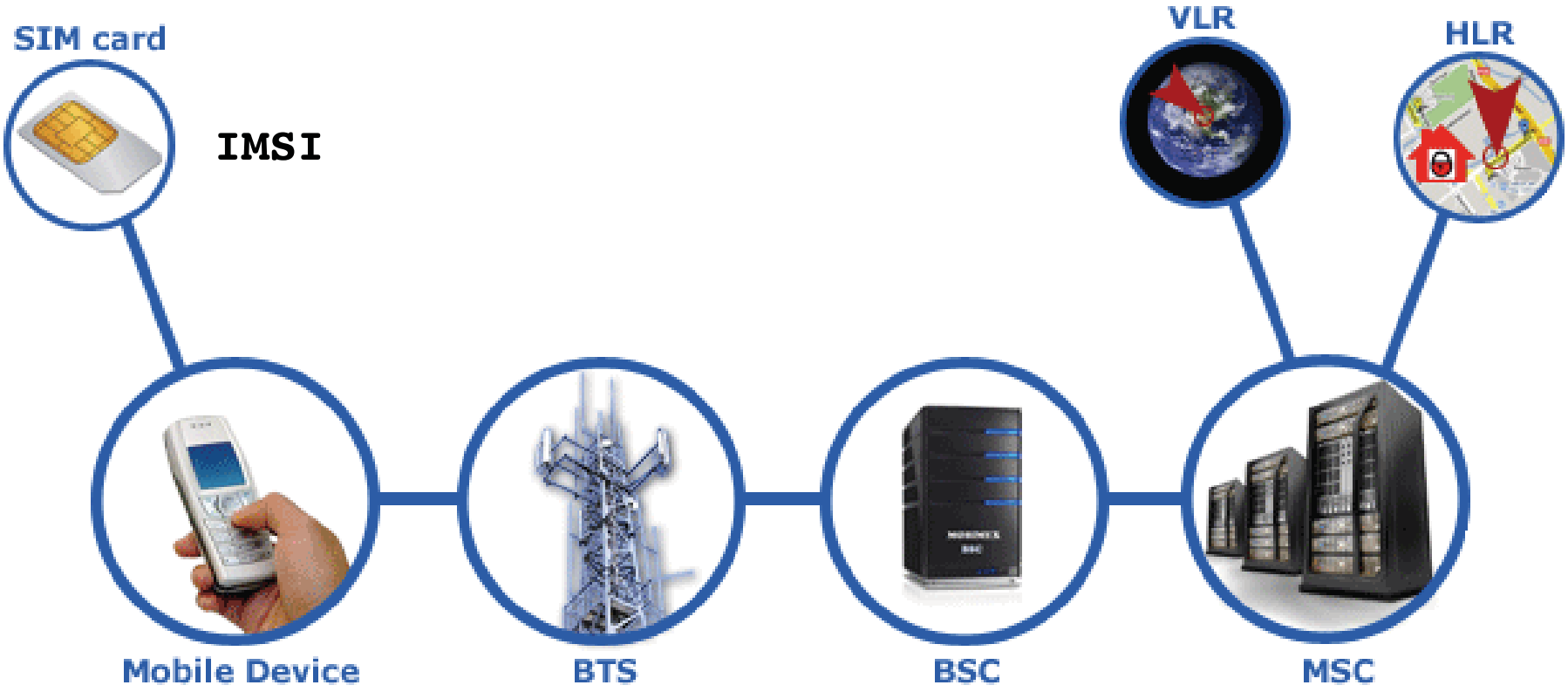

VLR
HLR
MSC
BSS
MS

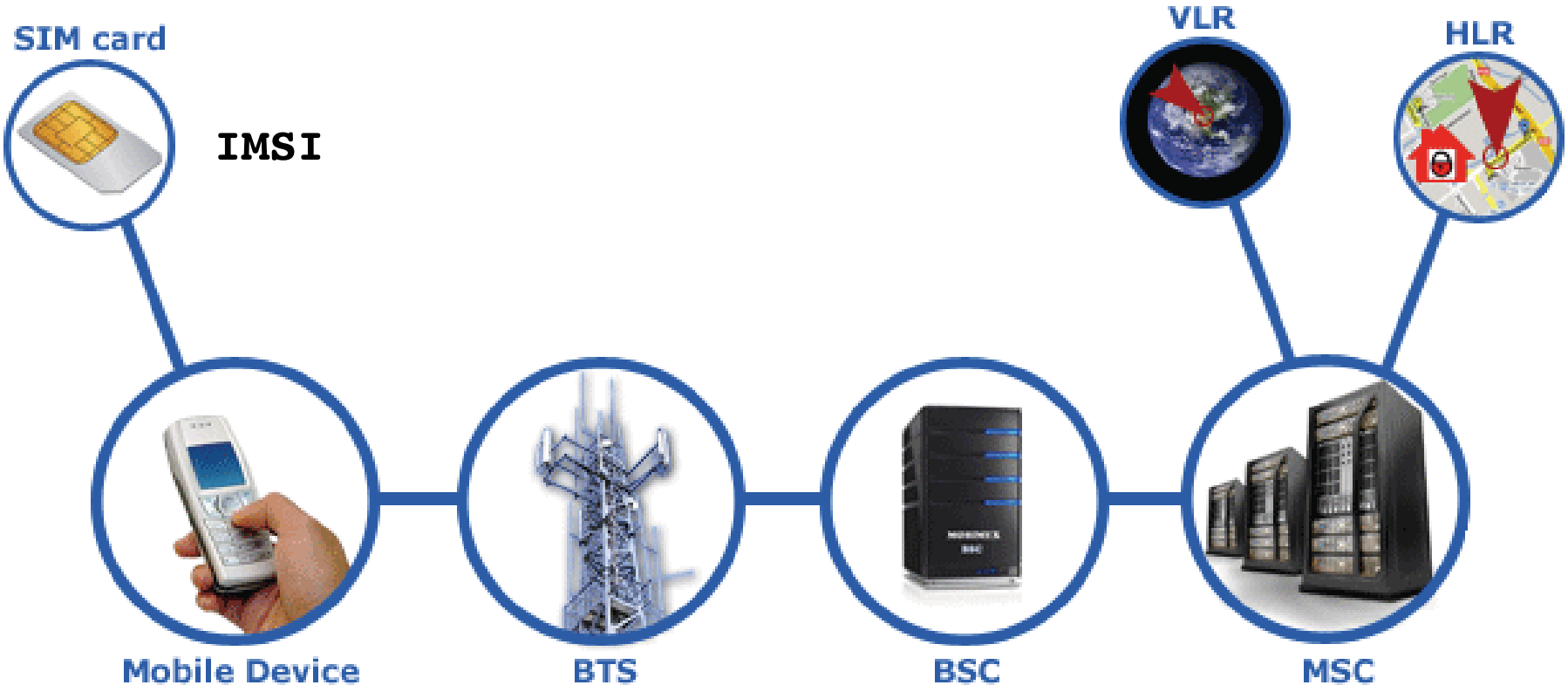
Mobile Identifiers

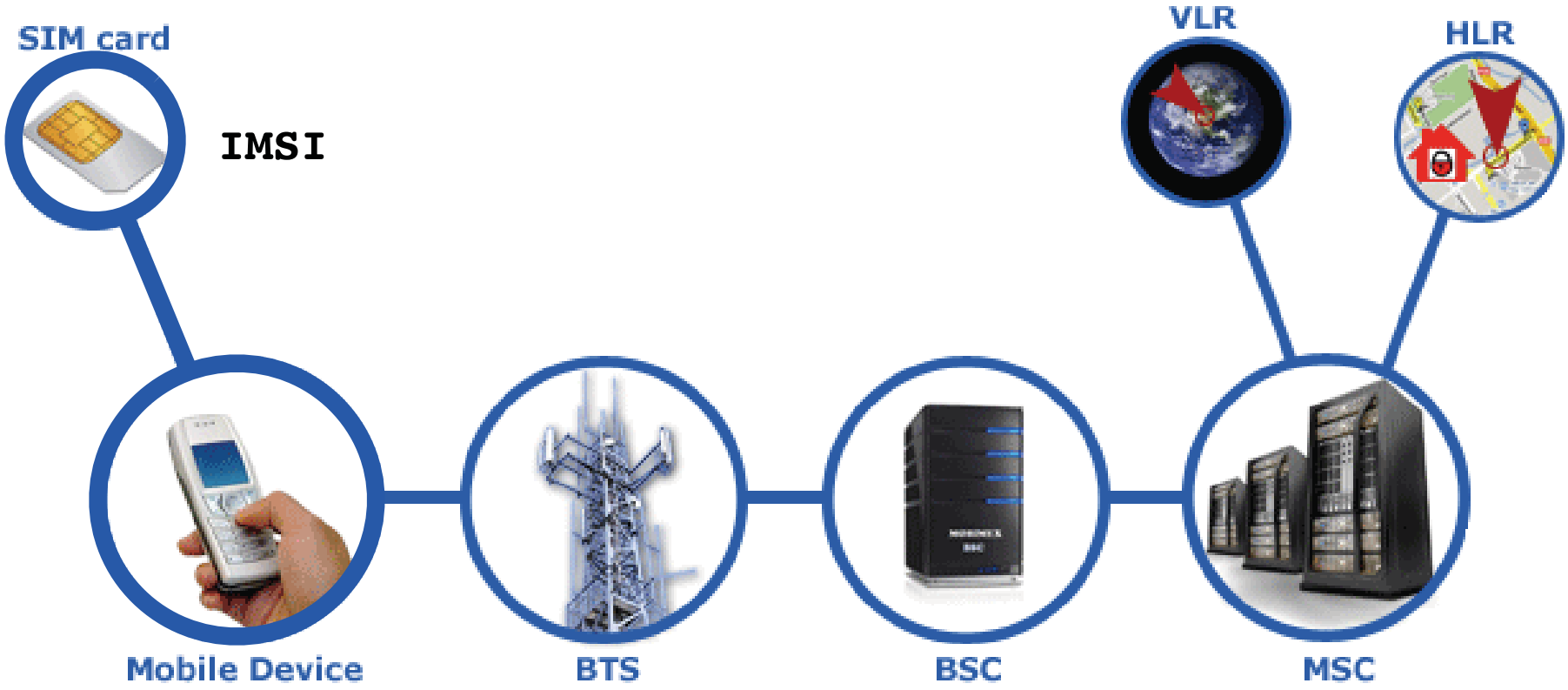
IMSI		
MCC	MNC	MSIN
3 digits	2 or 3 digits	Max 10 digits
<---------- Not to Exceed 15 Digits ---------->		

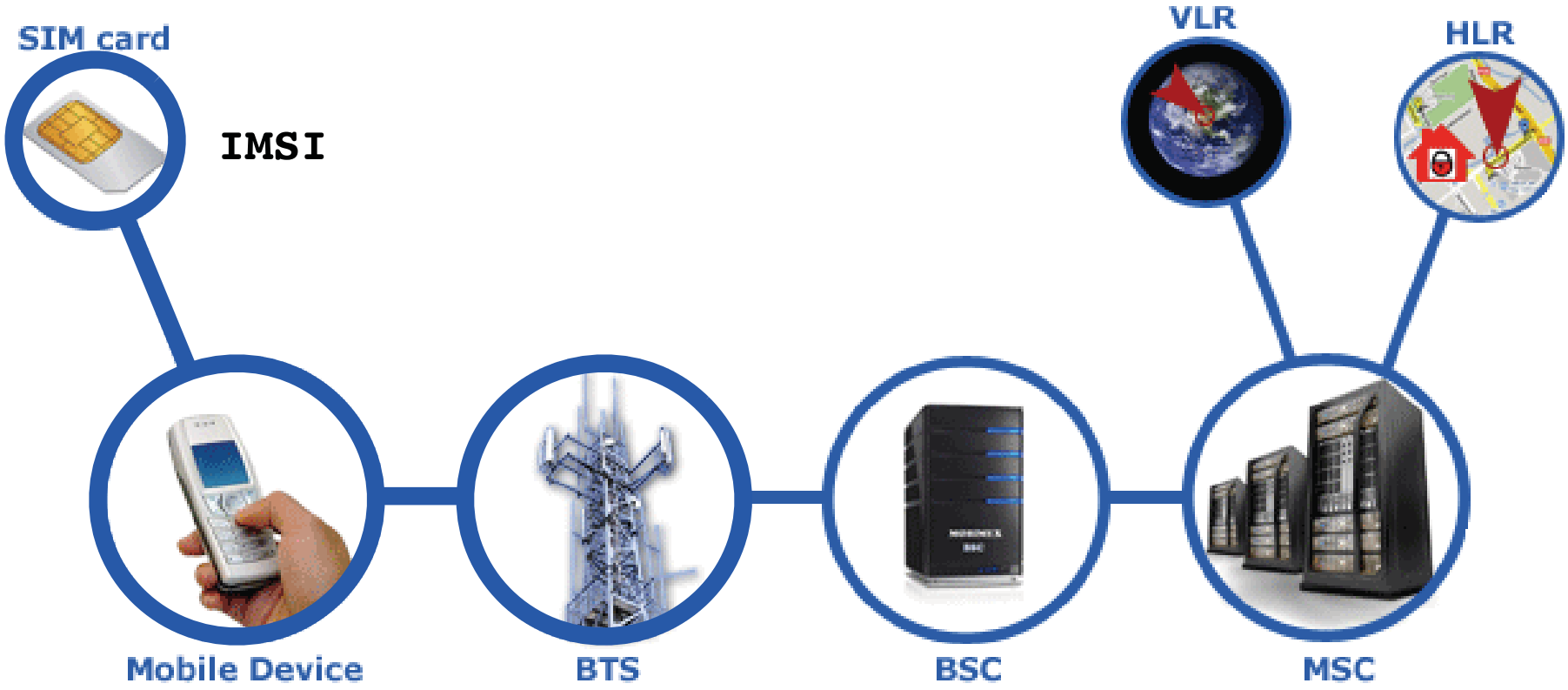
IMEI		
TAC	SNR	Spare
8 Digits	6 Digits	1 Digit

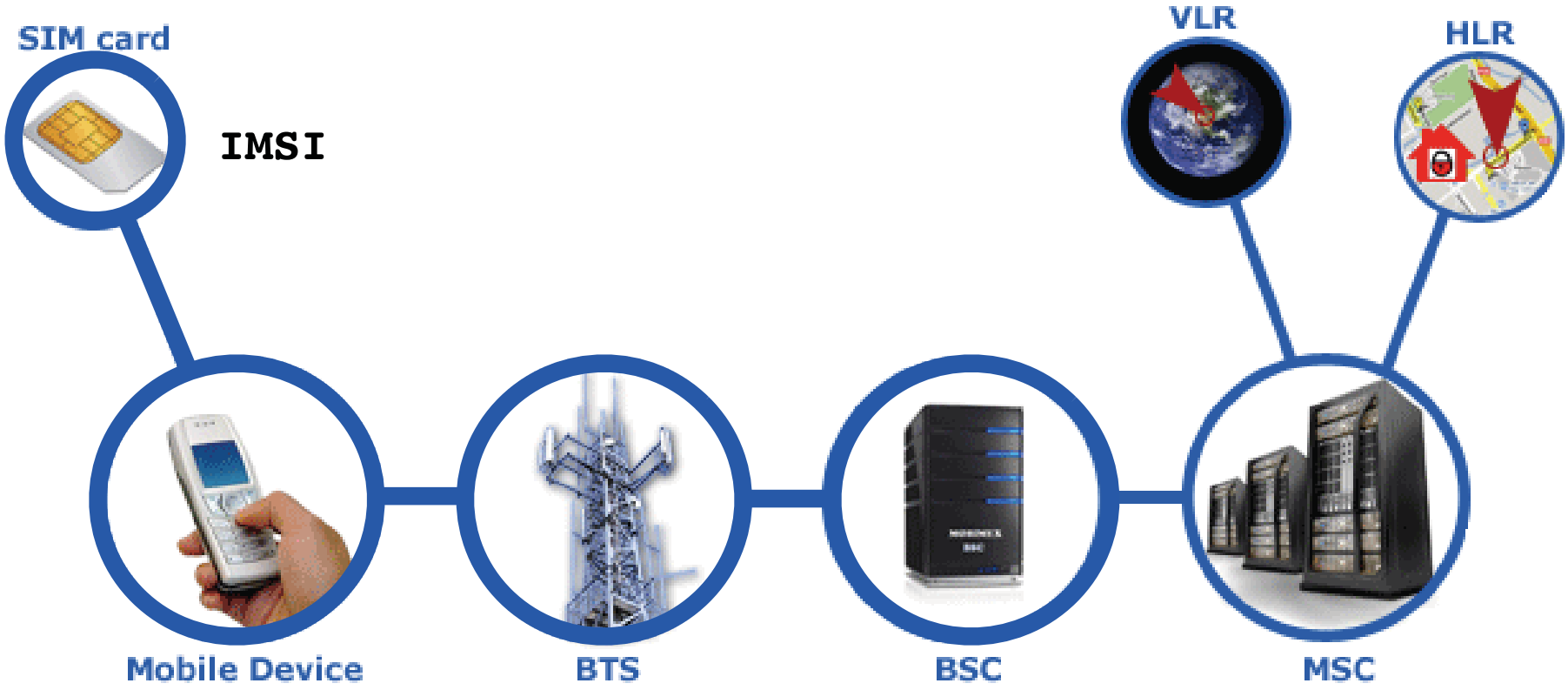

SIM card
VLR
HLR
Mobile Device
BTS
BSC
MSC

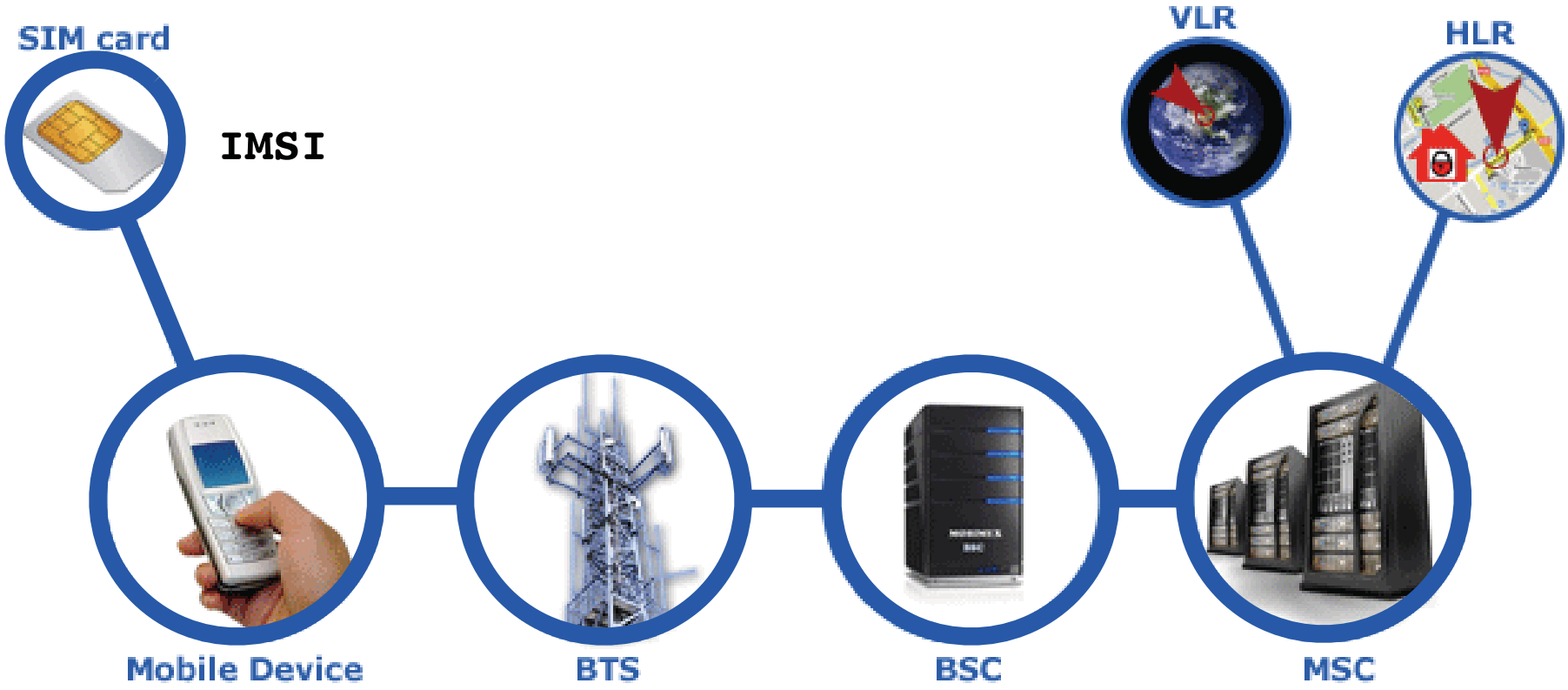

SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC

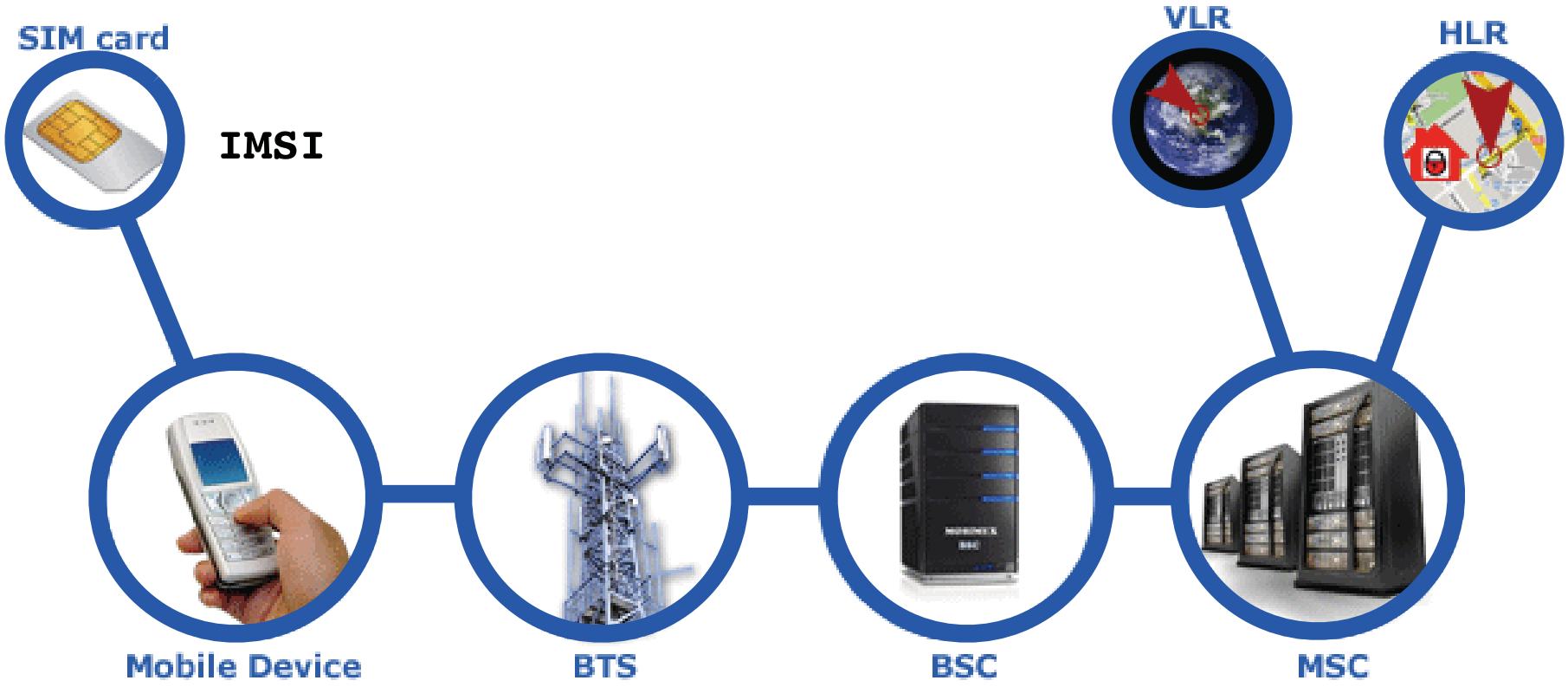

SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI


SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI

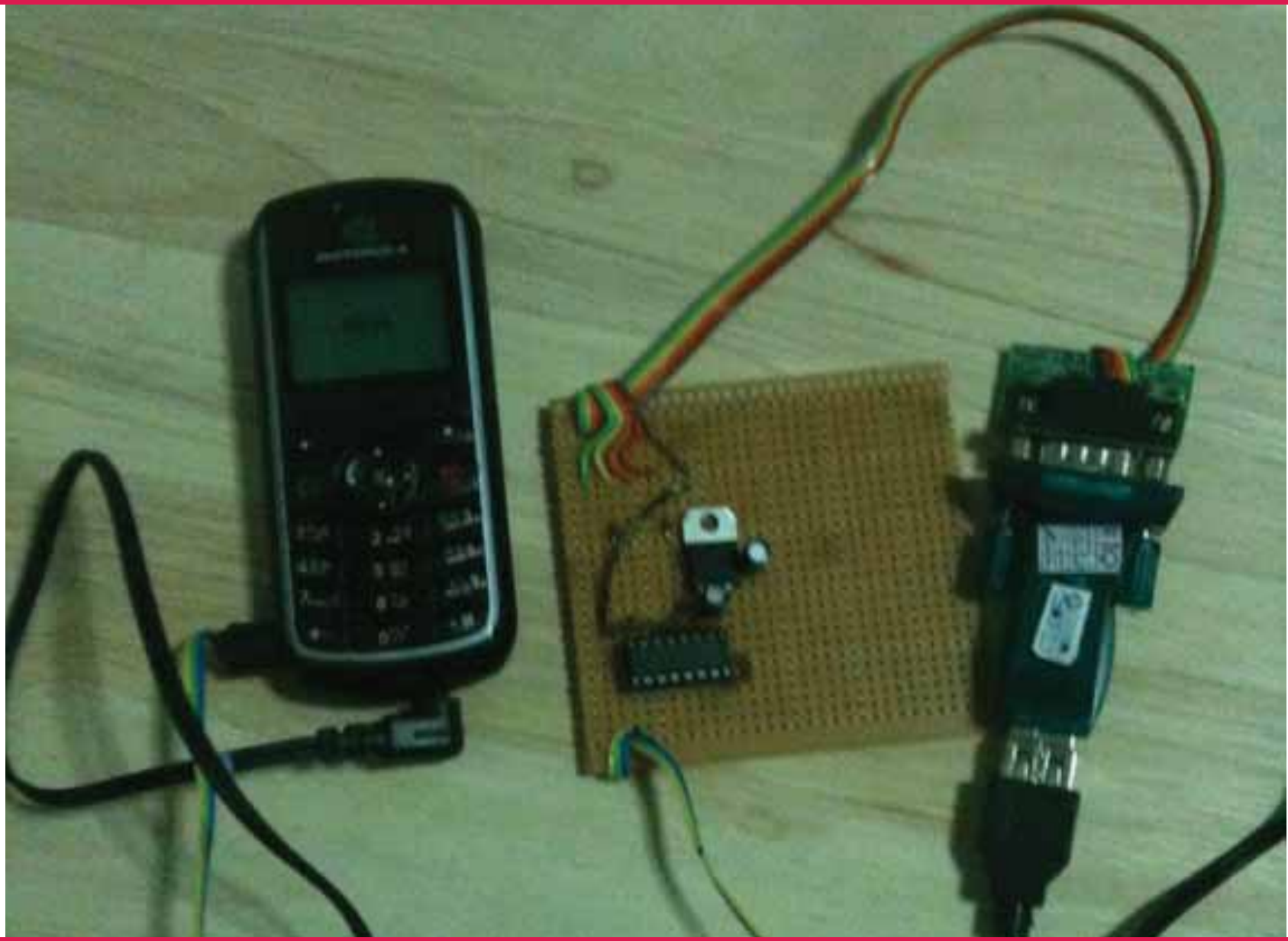

SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI


SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI


SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI


SIM card
IMSI
VLR
HLR
Mobile Device
BTS
BSC
MSC
IMEI

GSM Attacks

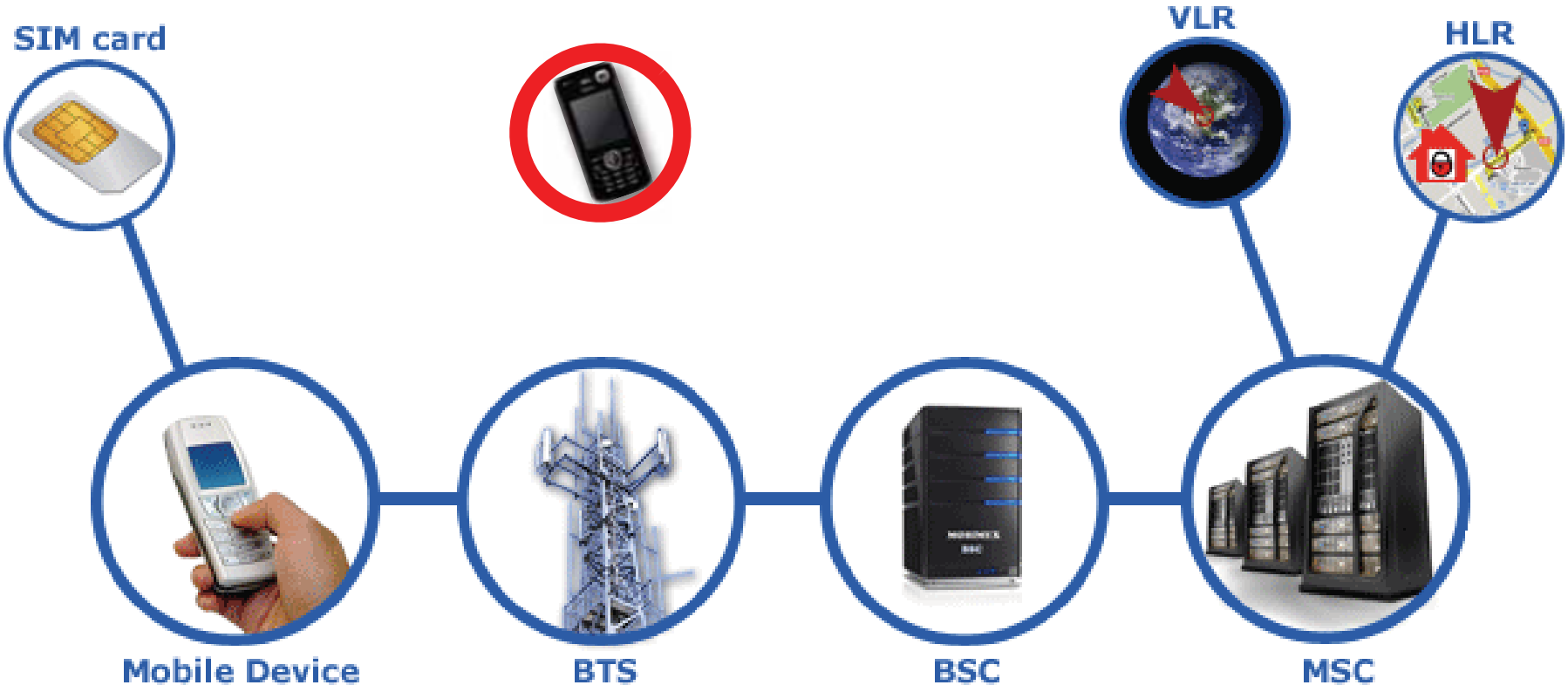


RACHell

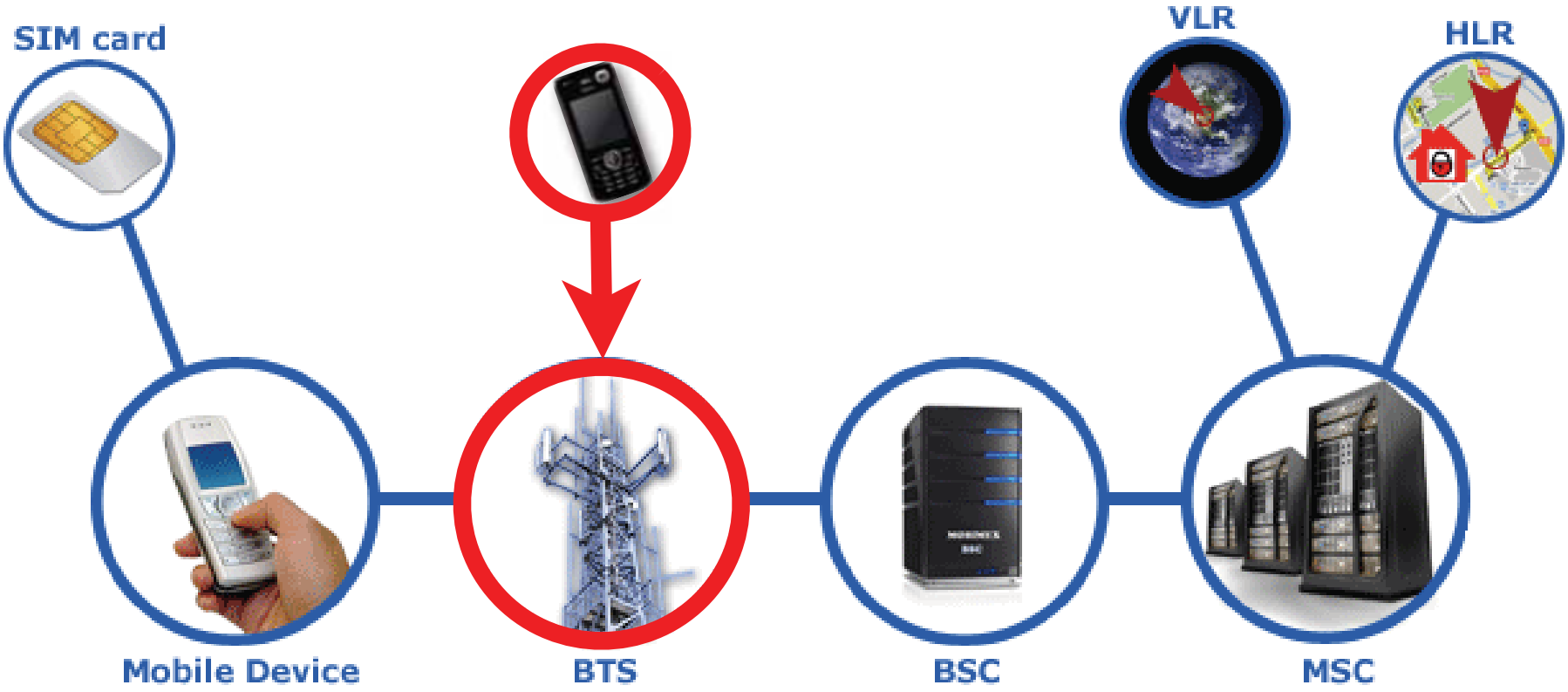
- Request channel allocation
- Flood the BSS with requests
- First announced by Dieter Spaar at DeepSec
- Prevent everyone from using that cell

RACHell

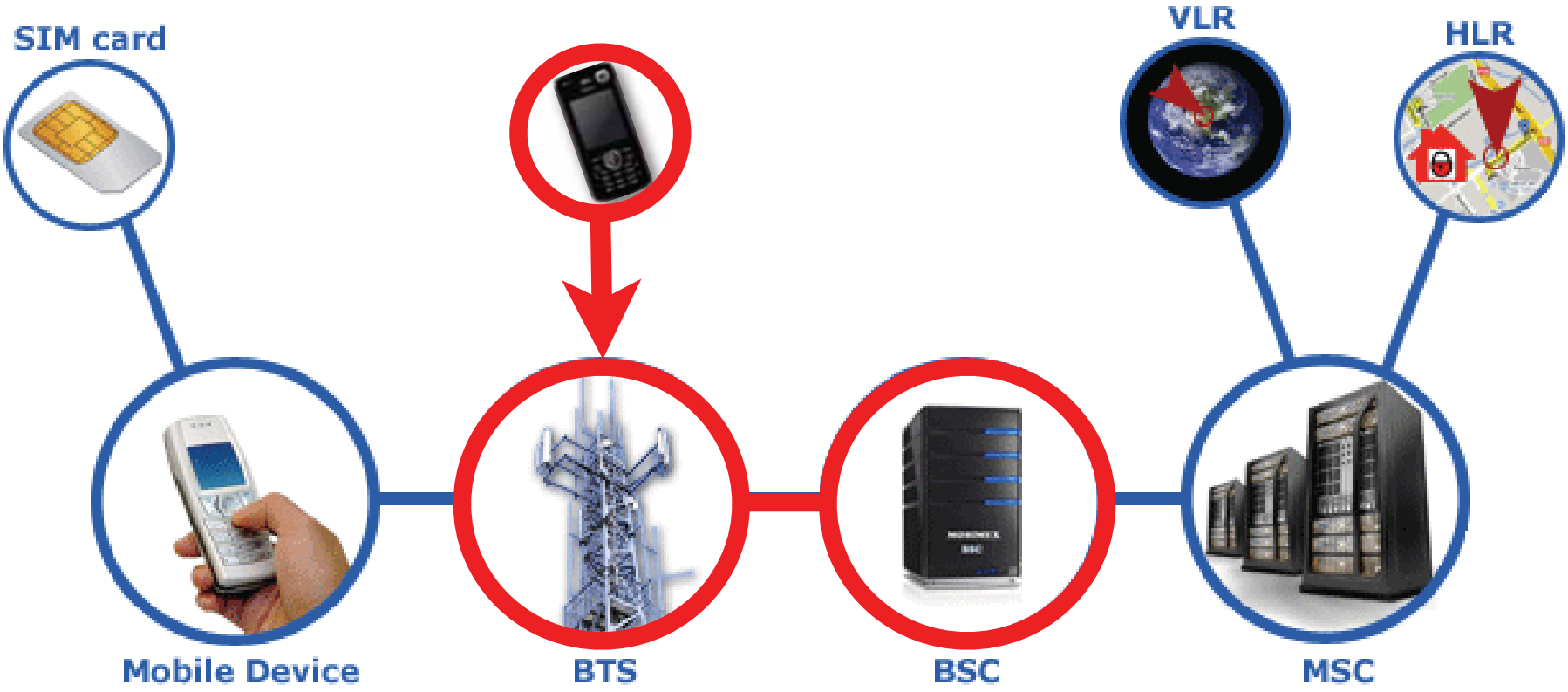
RACHell



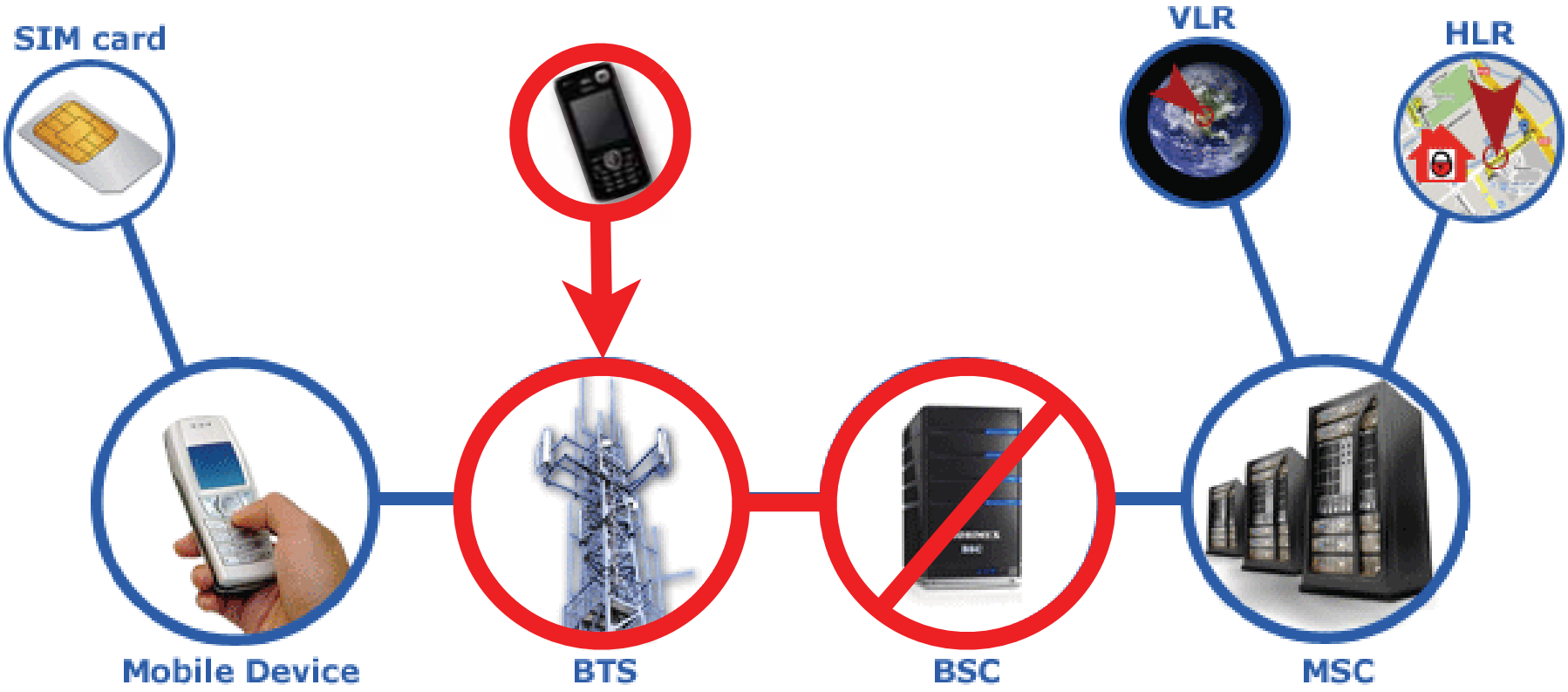
RACHell



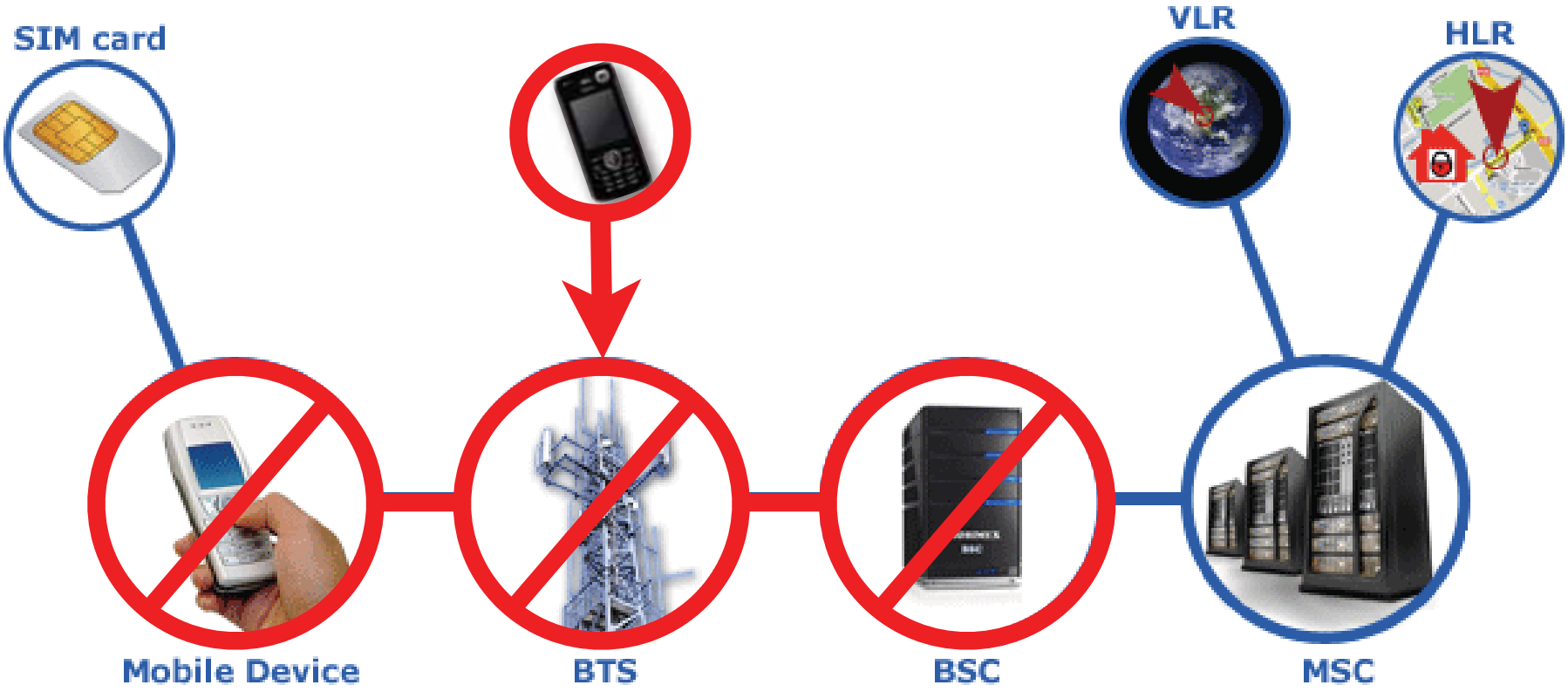
RACHell



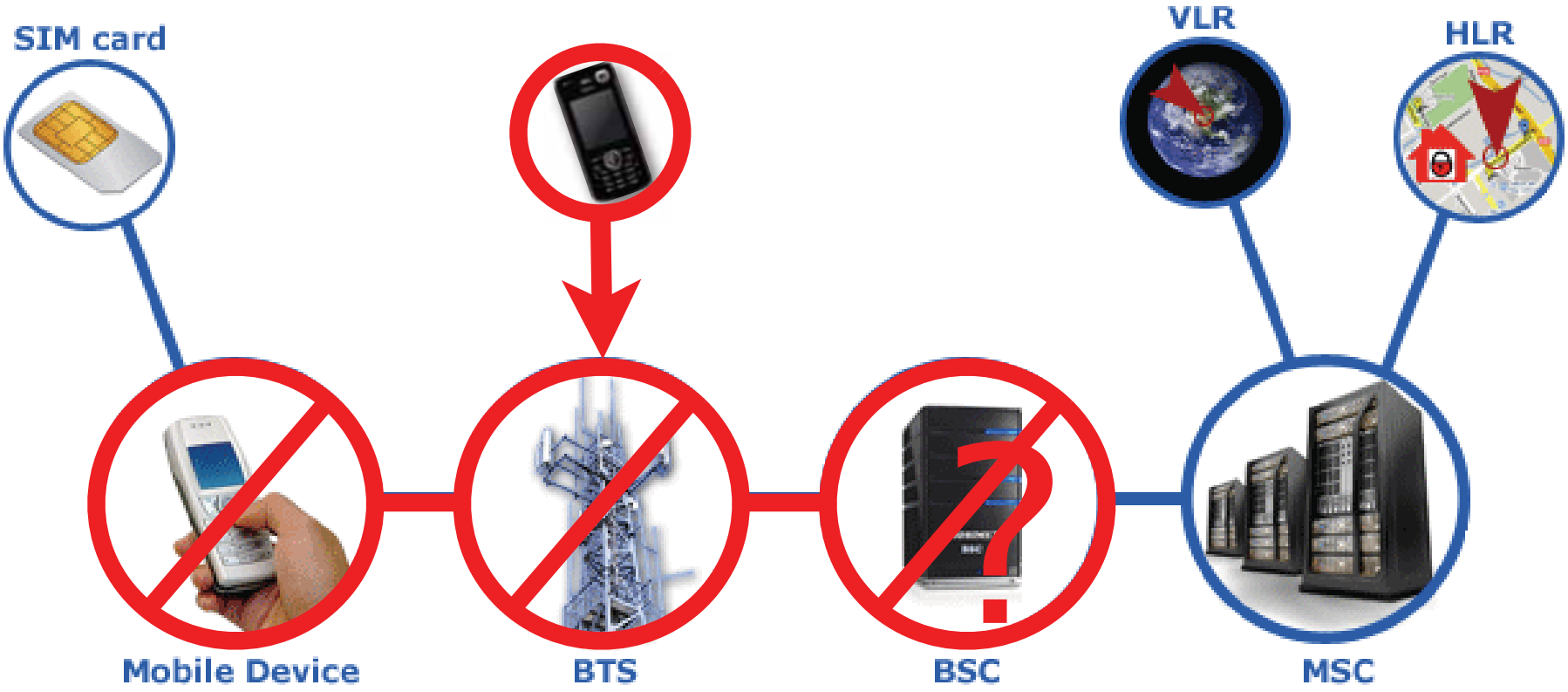
RACHell

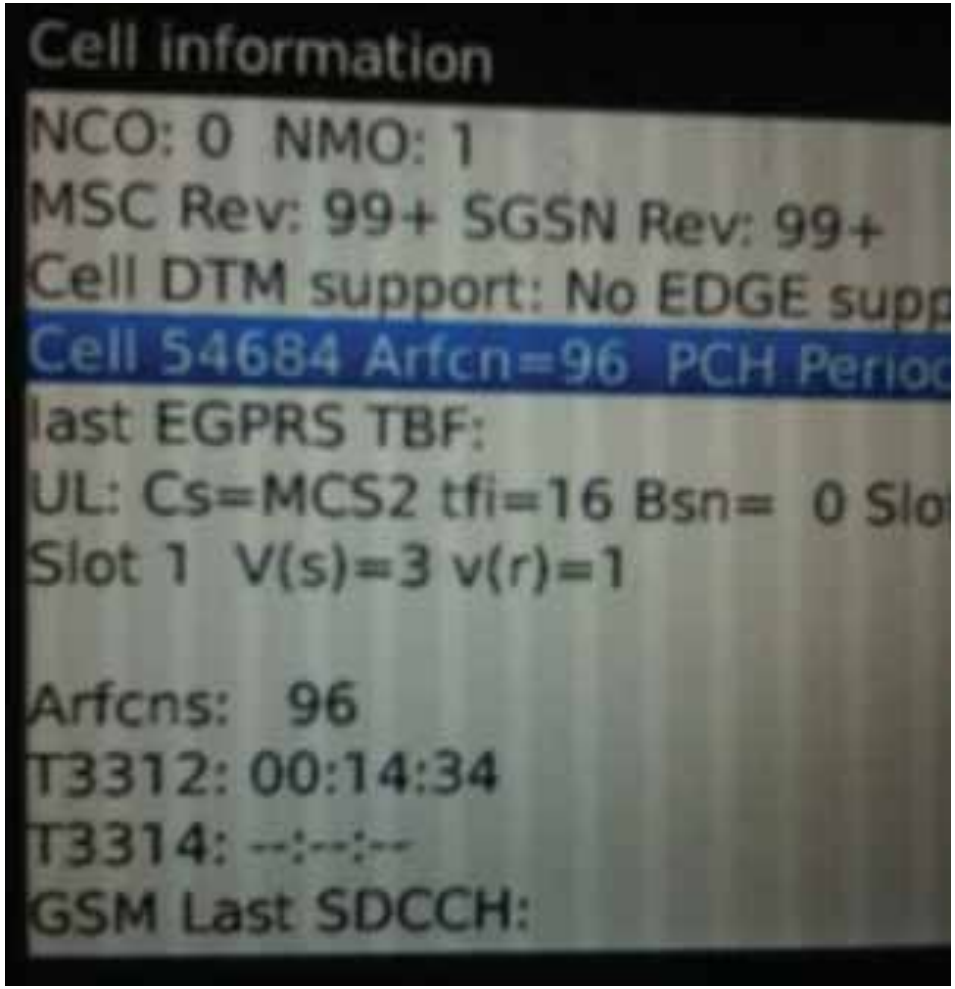


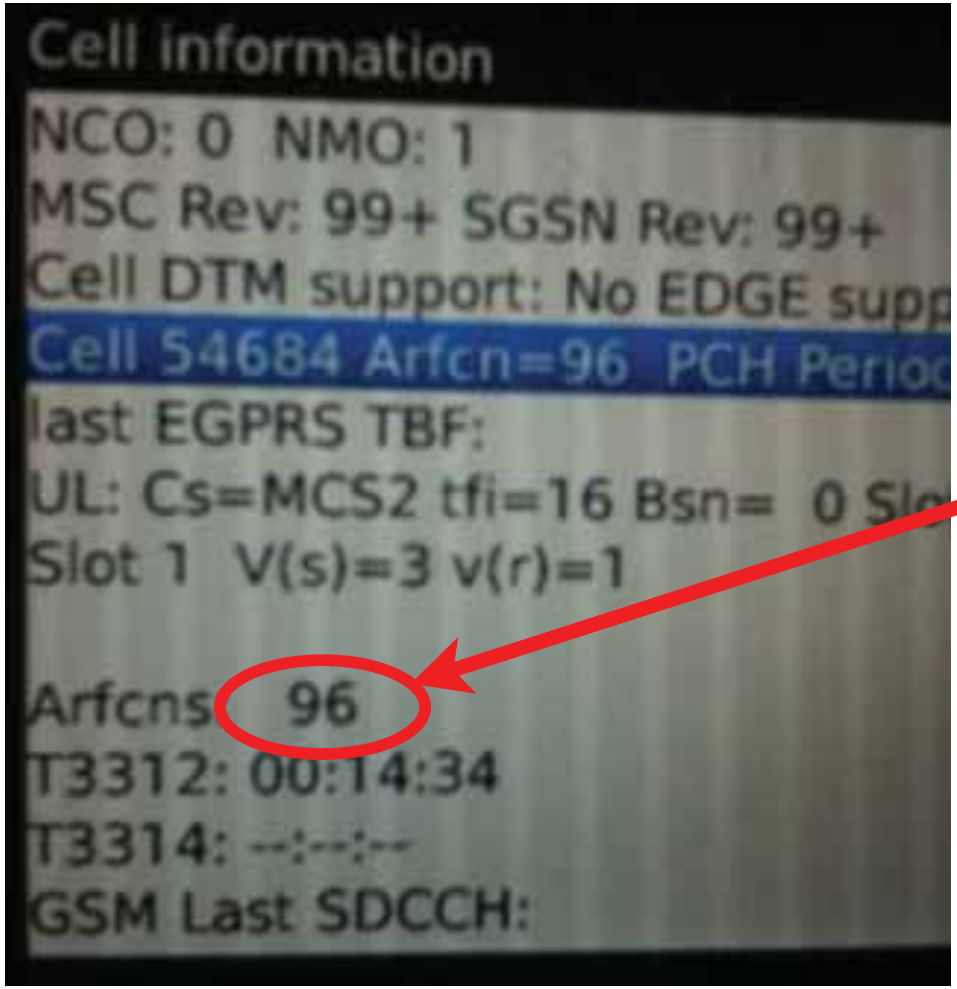
RACHell



RACHell




Cell information
NCO: 0 NMO: 1
MSC Rev: 99+ SGSN Rev: 99+
Cell DTM support: No EDGE supp
Cell 54684 Arfcn=96 PCH Period
last EGPRS TBF:
UL: Cs=MCS2 tfi=16 Bsn= 0 Slo
Slot 1 V(s)=3 v(r)=1
Arfcns: 96
T3312: 00:14:34
T3314: --:--:--
GSM Last SDCCH:


Cell information
NCO: 0 NMO: 1
MSC Rev: 99+ SGSN Rev: 99+
Cell DTM support: No EDGE supp
Cell 54684 Arfcn=96 PCH Period
last EGPRS TBF:
UL: Cs=MCS2 tfi=16 Bsn= 0 Slo
Slot 1 V(s)=3 v(r)=1
Arfcns 96
T3312: 00:14:34
T3314: --:--:--
GSM Last SDCCH:

Our Target

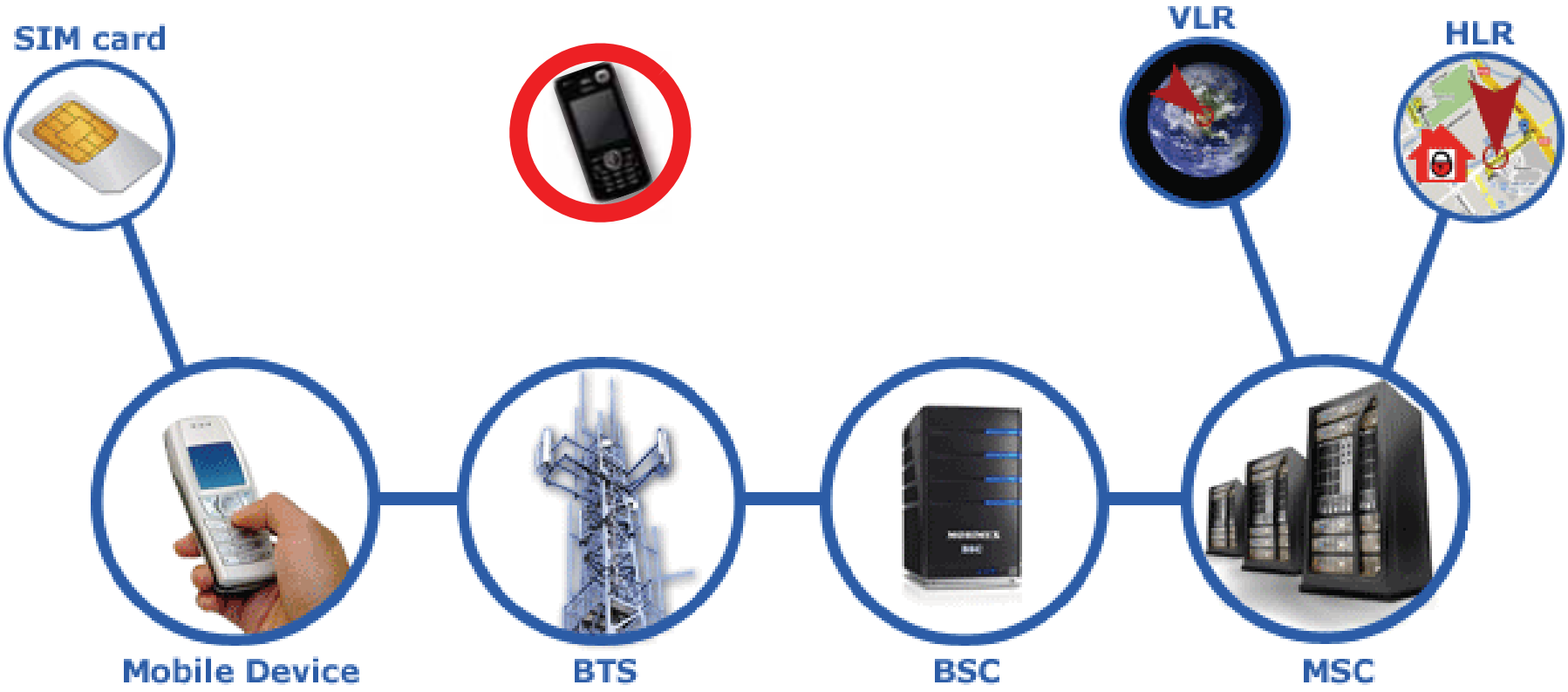
Demo – RACHell

IMSI Flood

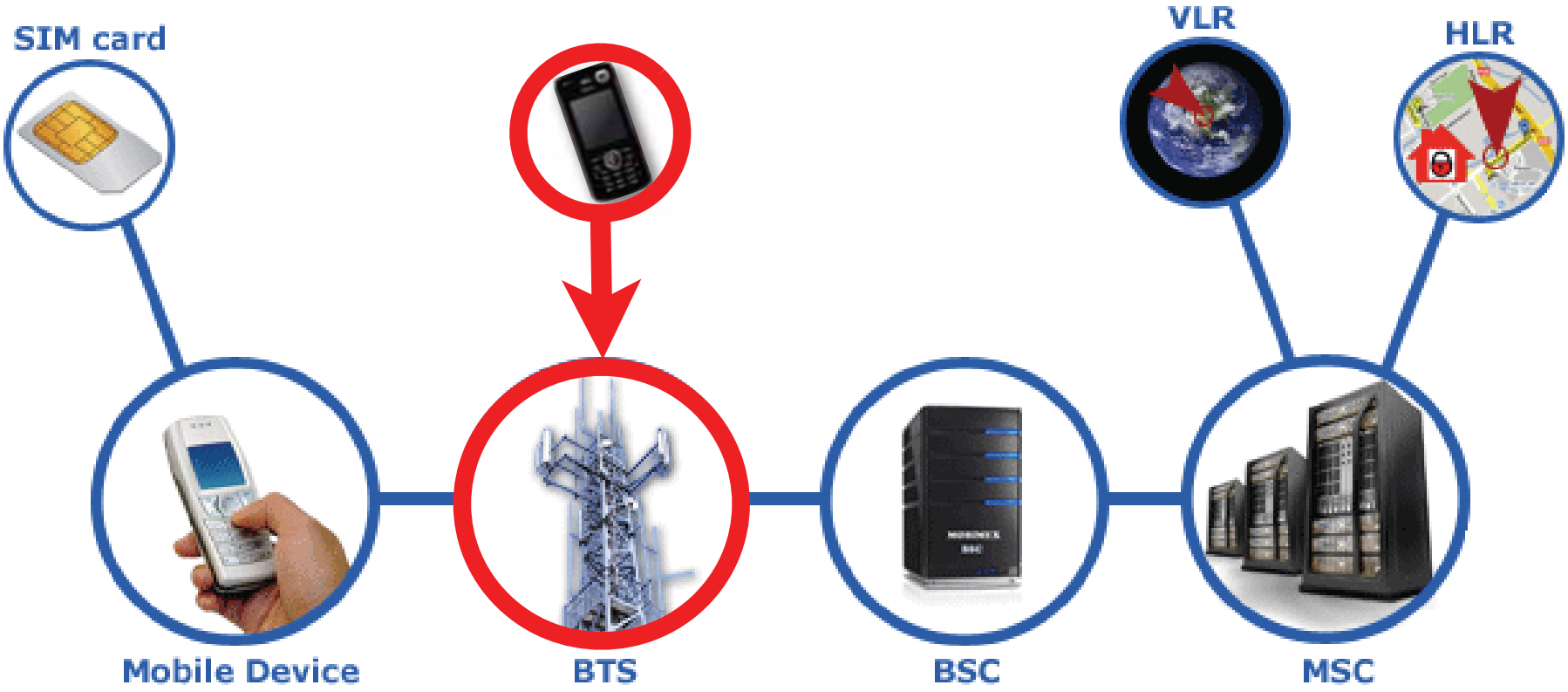
- Send IMSI ATTACH messages
- pre-authentication
- Overload the HLR/VLR infrastructure
- Prevent everyone using the network

IMSI Flood

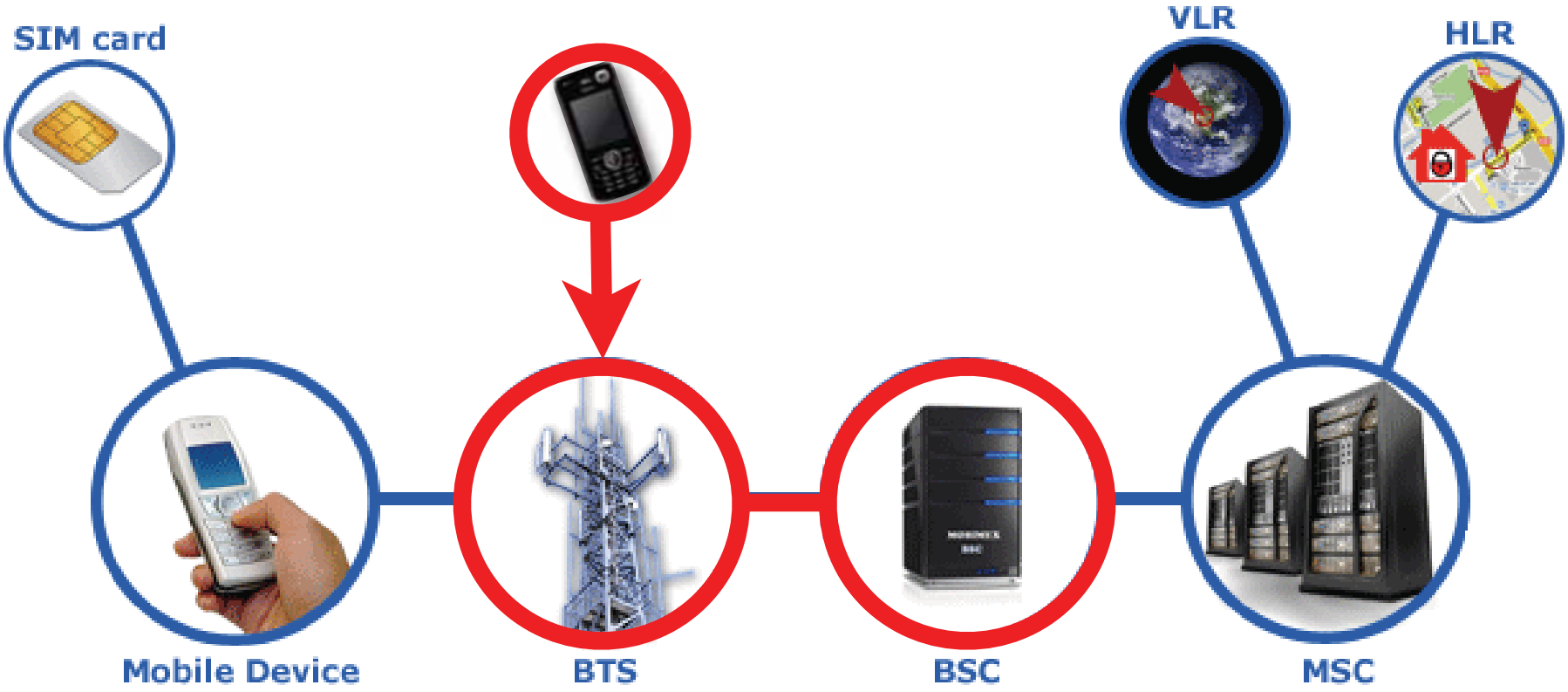
IMSI Flood



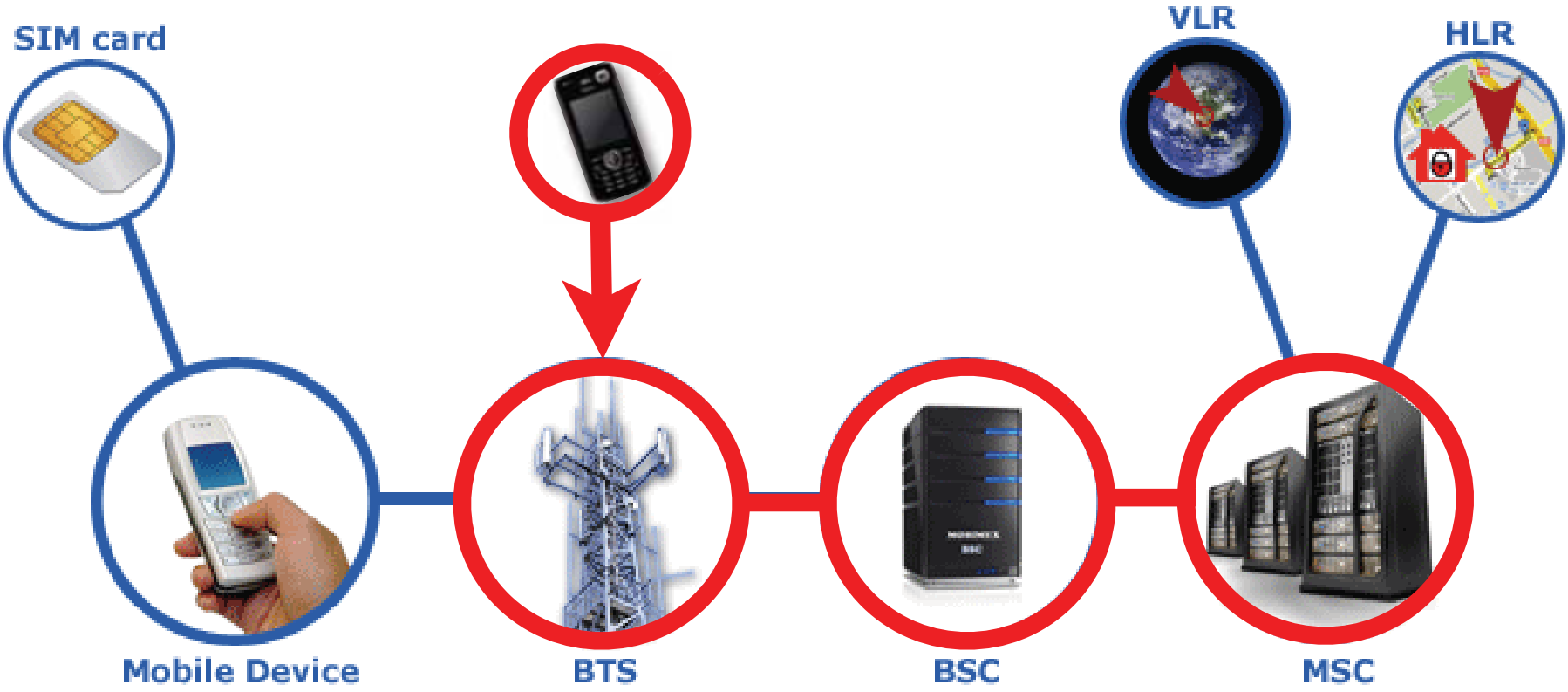
IMSI Flood



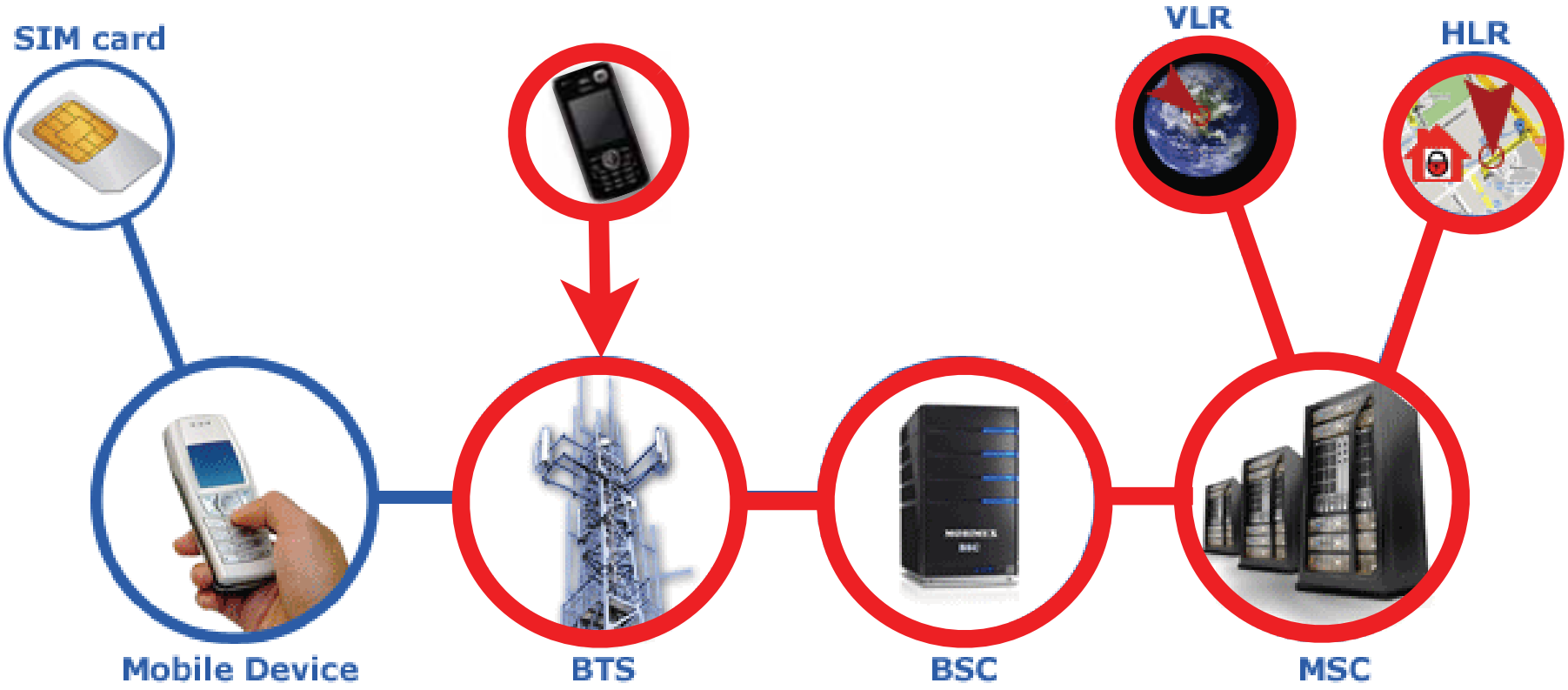
IMSI Flood



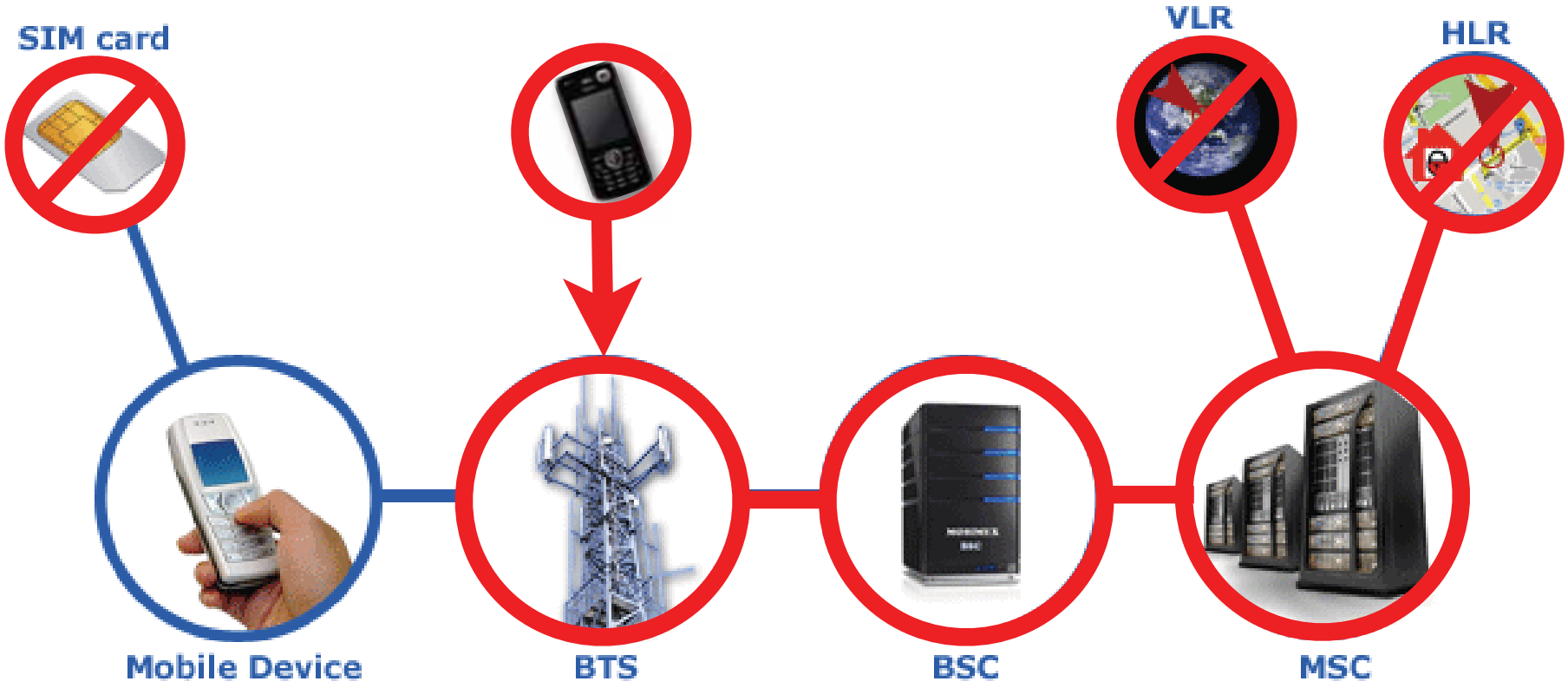
IMSI Flood



IMSI Flood



IMSI Flood

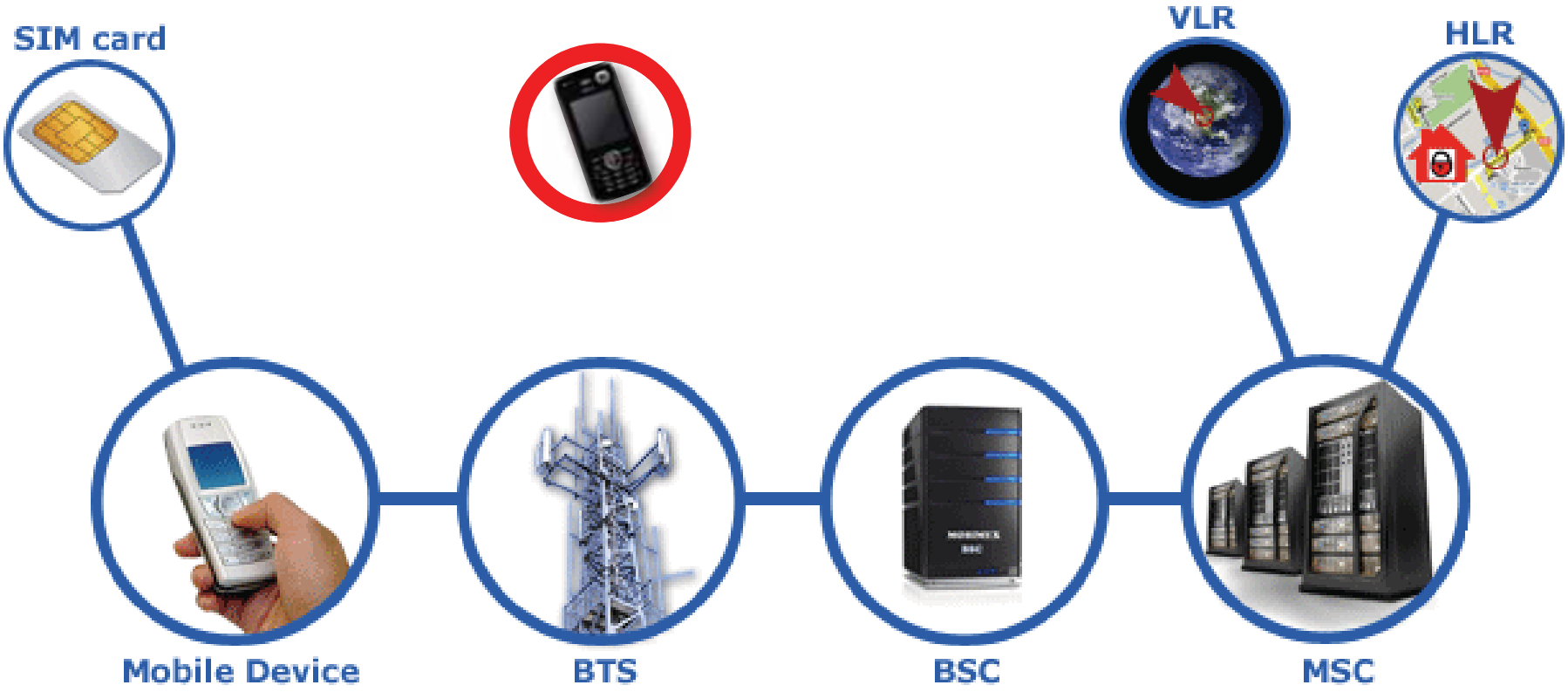


IMSI DETACH

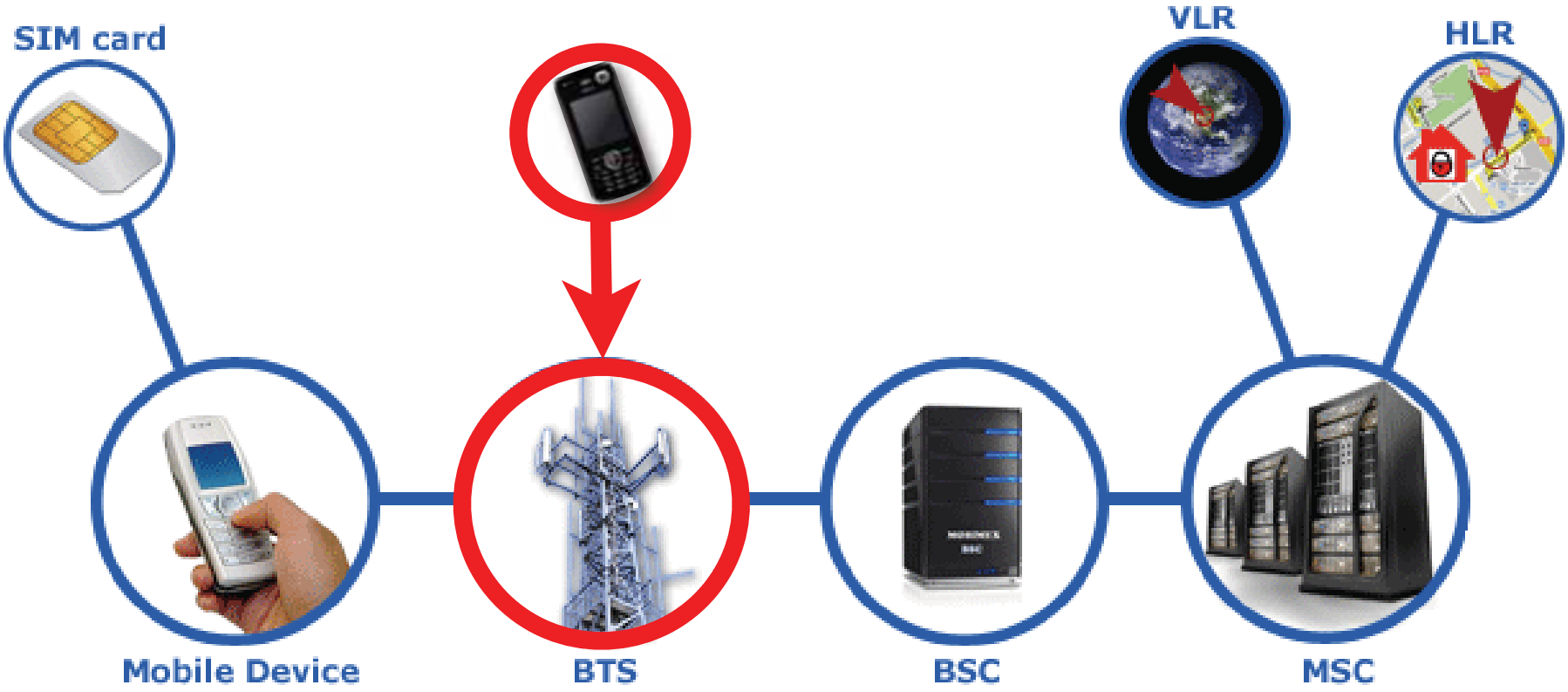
- Send multiple Location Update Requests including a spoofed IMSI
  - Unauthenticated
- Prevent SIM from receiving calls and SMS
- Discovered by Sylvain Munaut

IMSI DETACH

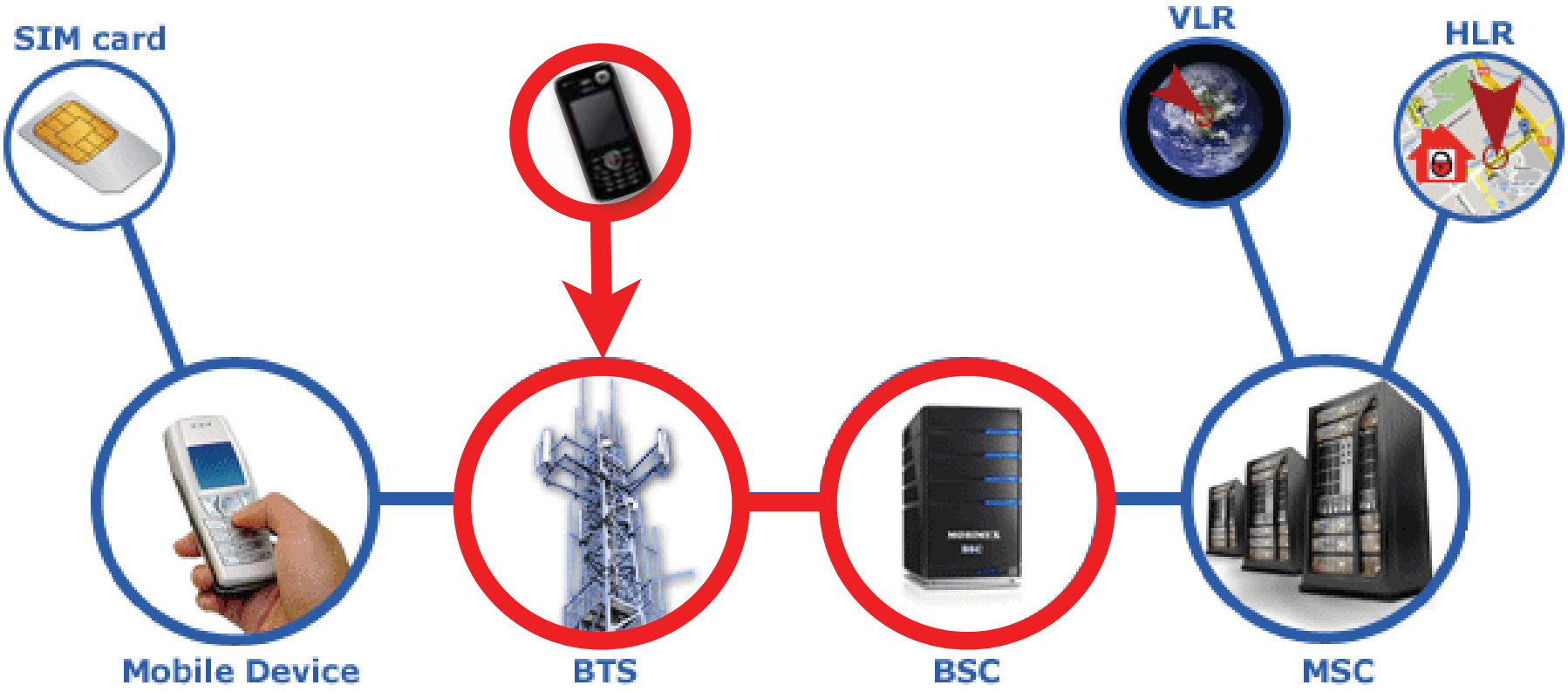
IMSI DETACH



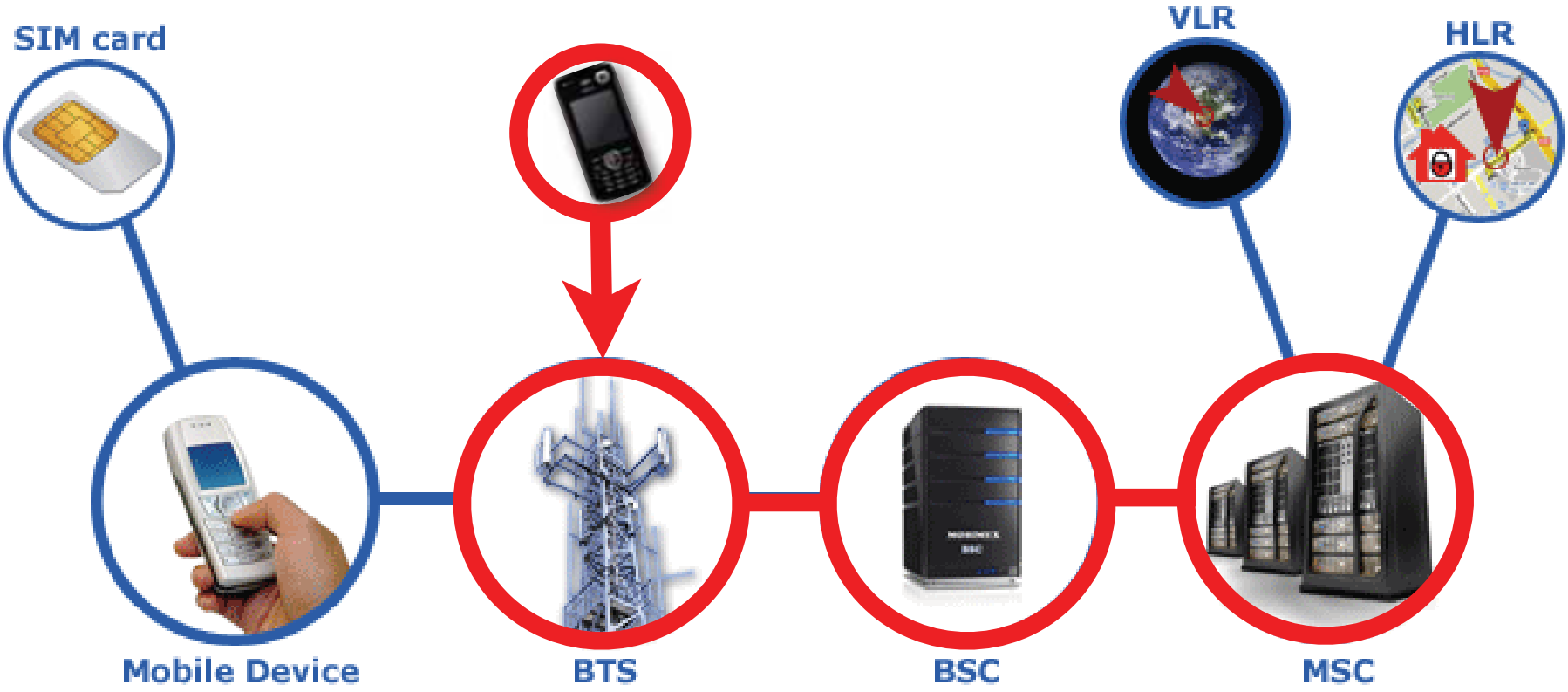
IMSI DETACH



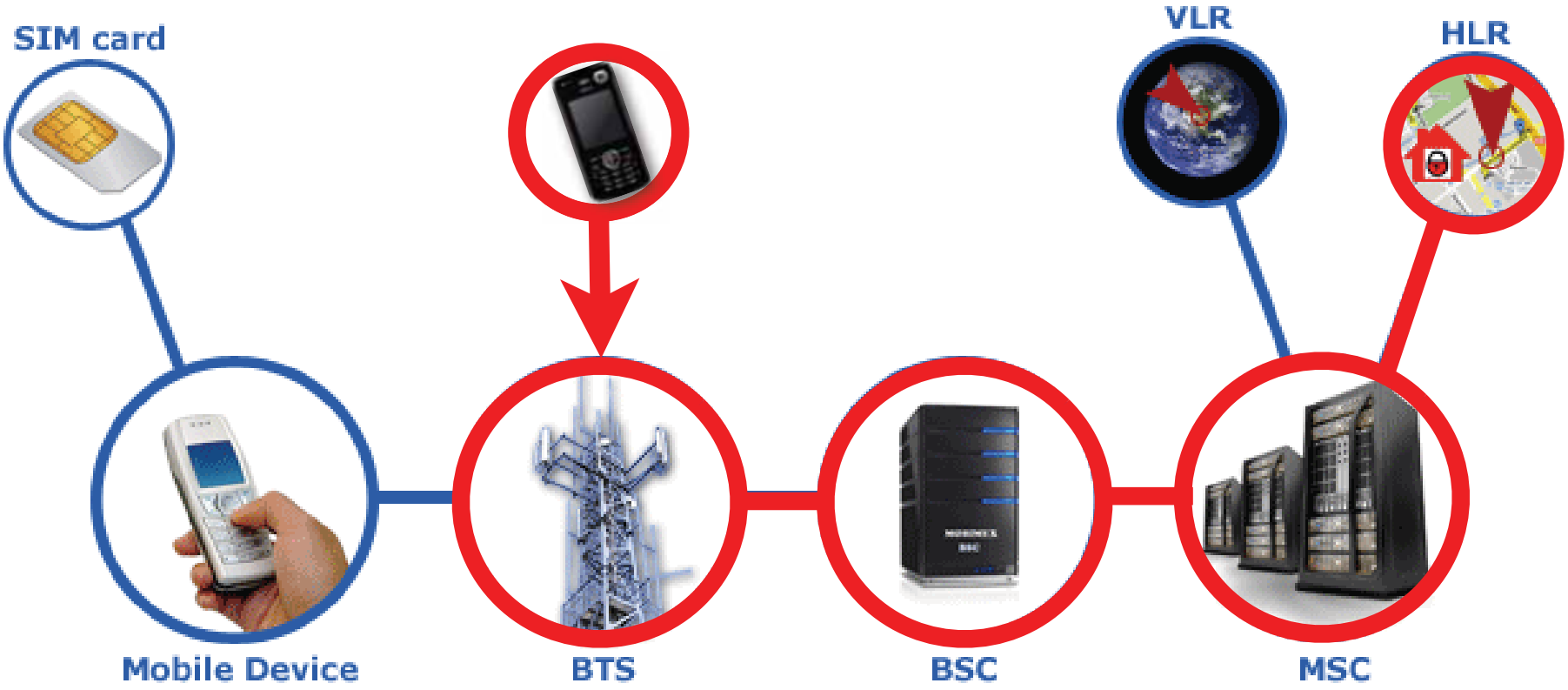
IMSI DETACH



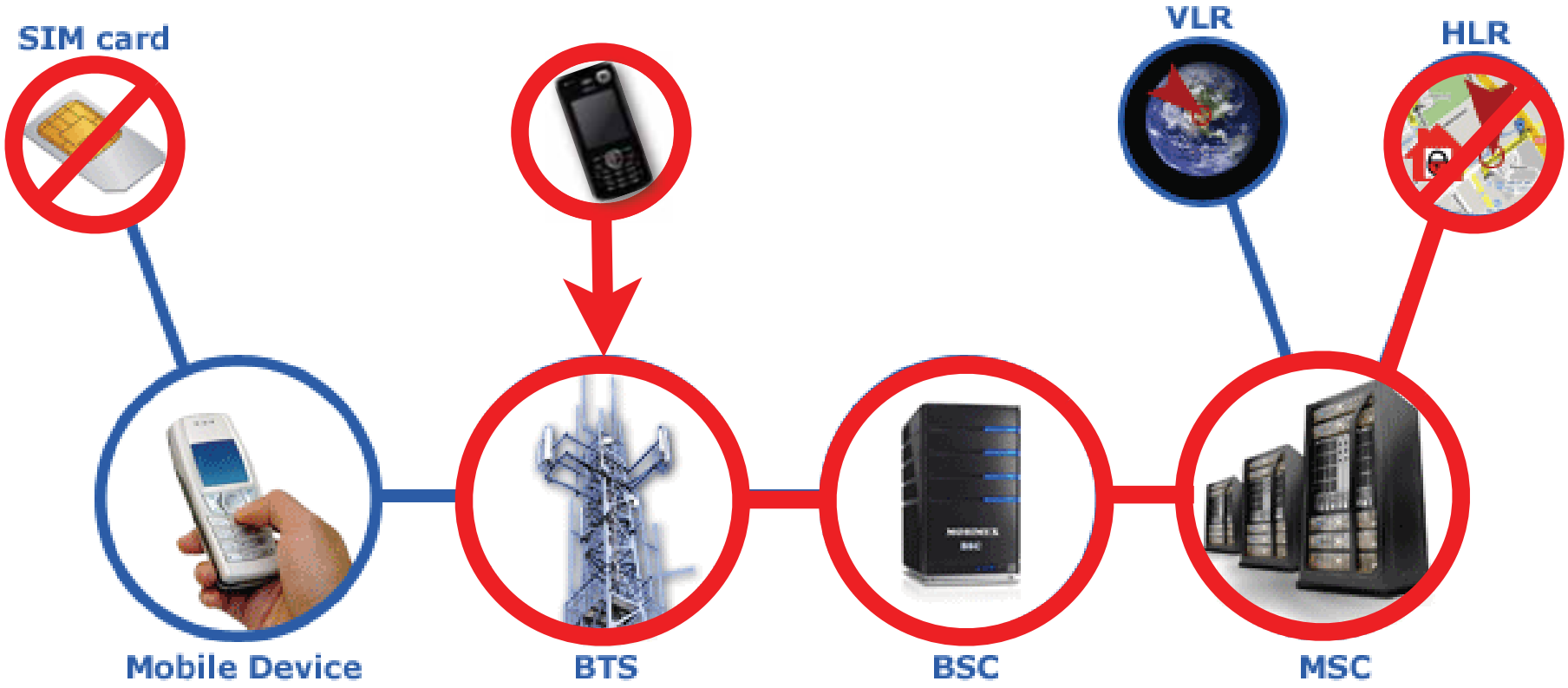
IMSI DETACH



IMSI DETACH



IMSI DETACH



How hard to get an IMSI?

Supports MCC / MNC MSC IMSI.

RoutoMessaging HLR Lookup supports	MCC / MNC	MSC	IMSI	Invalid Number	Price €
	✓	✓	✓	✓	0.006

Baseband Fuzzing

How to make a smartphone

Two separate computers

Two separate computers

Baseband

- Controls the radio
- Separate CPU and code base
- RTOS
- Written in C
- Typically legacy code base (decades)

GSM Frame Delivery

- OpenBTS + XML-RPC
  - lch_open(char * IMSI)
  - lch_send(int fd, char *buf, size_t len)
  - lch_recv(int fd, char *buf, size_t len)
  - lch_close(int fd)

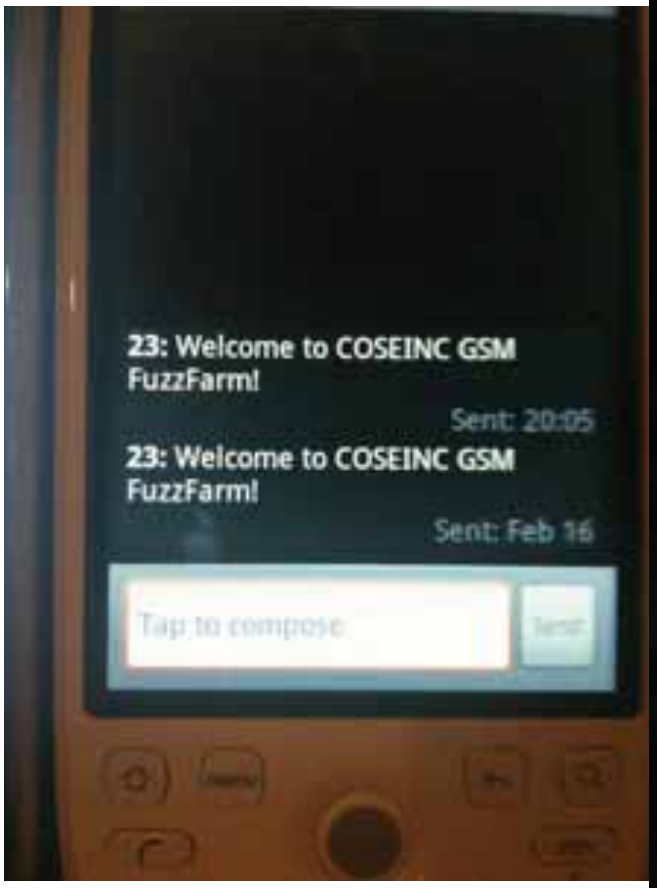
GSM Fuzzing Framework

- USRP + OpenBTS for delivery
- GSM900 band
- BugMine case generation & mutation
- No Instrumentation
  - Very bad visibility on bugs

Coseinc GSM FuzzFarm

- Targetting
  - iPhone
  - HTC (Android)
  - Palm Pre
  - Blackberry
  - Nokia


SAMSUNG
23
Welcome to COSEINC GSM FuzzFarm!
Press unlock and then * key


23: Welcome to COSEINC GSM FuzzFarm!
Sent: 20:05
23: Welcome to COSEINC GSM FuzzFarm!
Sent: Feb 16
Tap to compose


TH GSM
18:59
Messages (4)
23
Edit
Call
Add to Contacts
Welcome to COSEINC GSM FuzzFarm!

Conclusion

GSM Trouble

- GSM is no longer a walled garden
- GSM spec has security problems
- Expect many more issues as OSS reduces costs for entry

Future work

- More GSM stack fuzzing
- Next gen protocol stacks

Thanks to

Harald Welte, Osmocom-bb &
OpenBTS

Questions?