Fig. 1

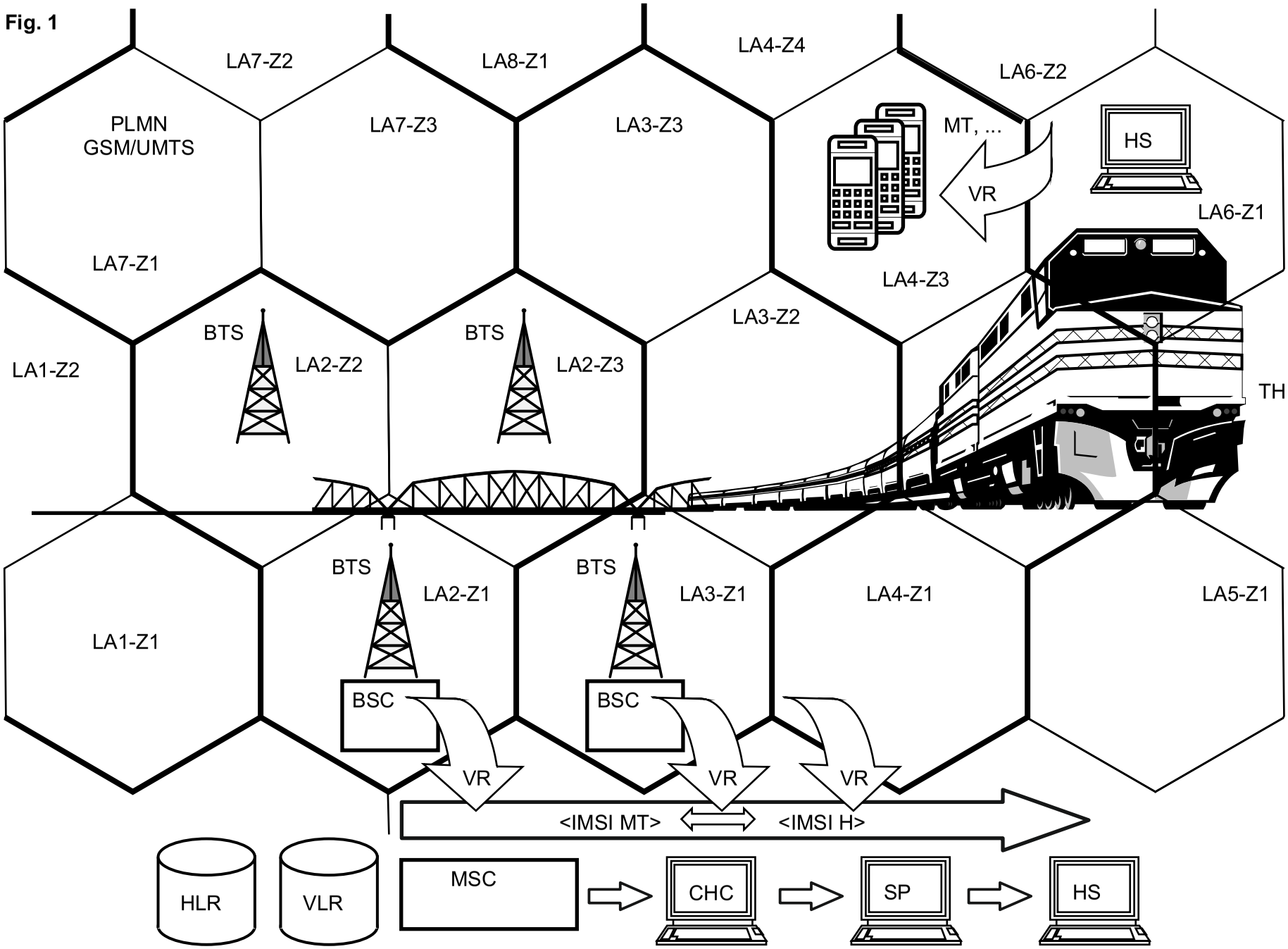

LA7-Z2
LA8-Z1
LA4-Z4
LA6-Z2
PLMN
GSM/UMTS
LA7-Z3
LA3-Z3
MT, ...
HS
VR
LA6-Z1
LA7-Z1
LA4-Z3
LA3-Z2
BTS
BTS
LA1-Z2
LA2-Z2
LA2-Z3
TH
BTS
BTS
LA2-Z1
LA3-Z1
LA4-Z1
LA5-Z1
LA1-Z1
BSC
BSC
VR
VR
VR
<IMSI MT>
<IMSI H>
HLR
VLR
MSC
CHC
SP
HS

Fig. 2a

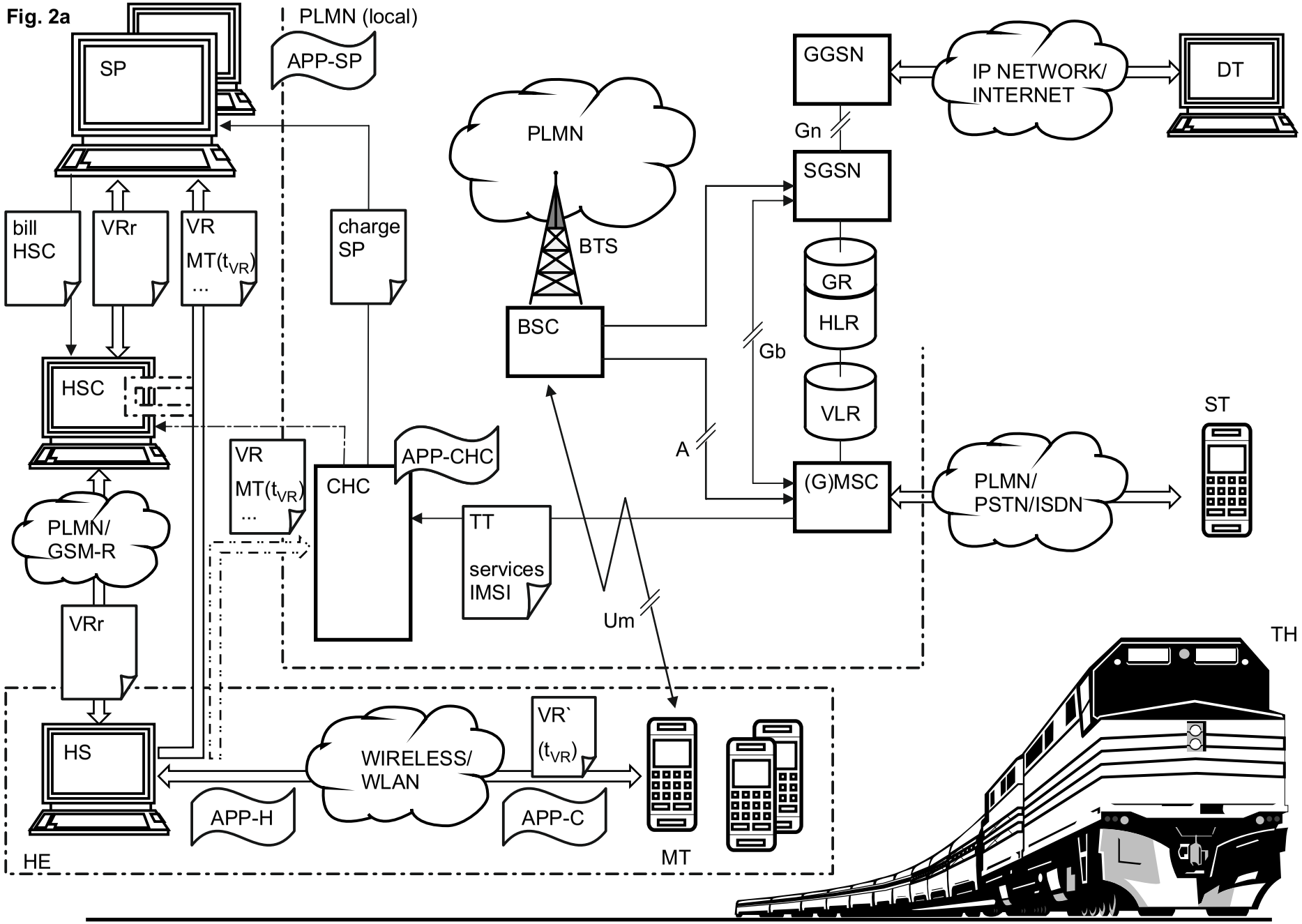

SP
PLMN (local)
APP-SP
bill
HSC
VRr
VR
MT(t_{VR})
...
charge
SP
PLMN
BTS
BSC
GGSN
IP NETWORK/
INTERNET
DT
Gn
SGSN
GR
HLR
Gb
VLR
A
(G)MSC
PLMN/
PSTN/ISDN
ST
HSC
VR
MT(t_{VR})
...
CHC
APP-CHC
TT
services
IMSI
Um
PLMN/
GSM-R
VRr
HS
WIRELESS/
WLAN
VR`
(t_{VR})
APP-H
APP-C
HE
MT
TH

FIG. 2b

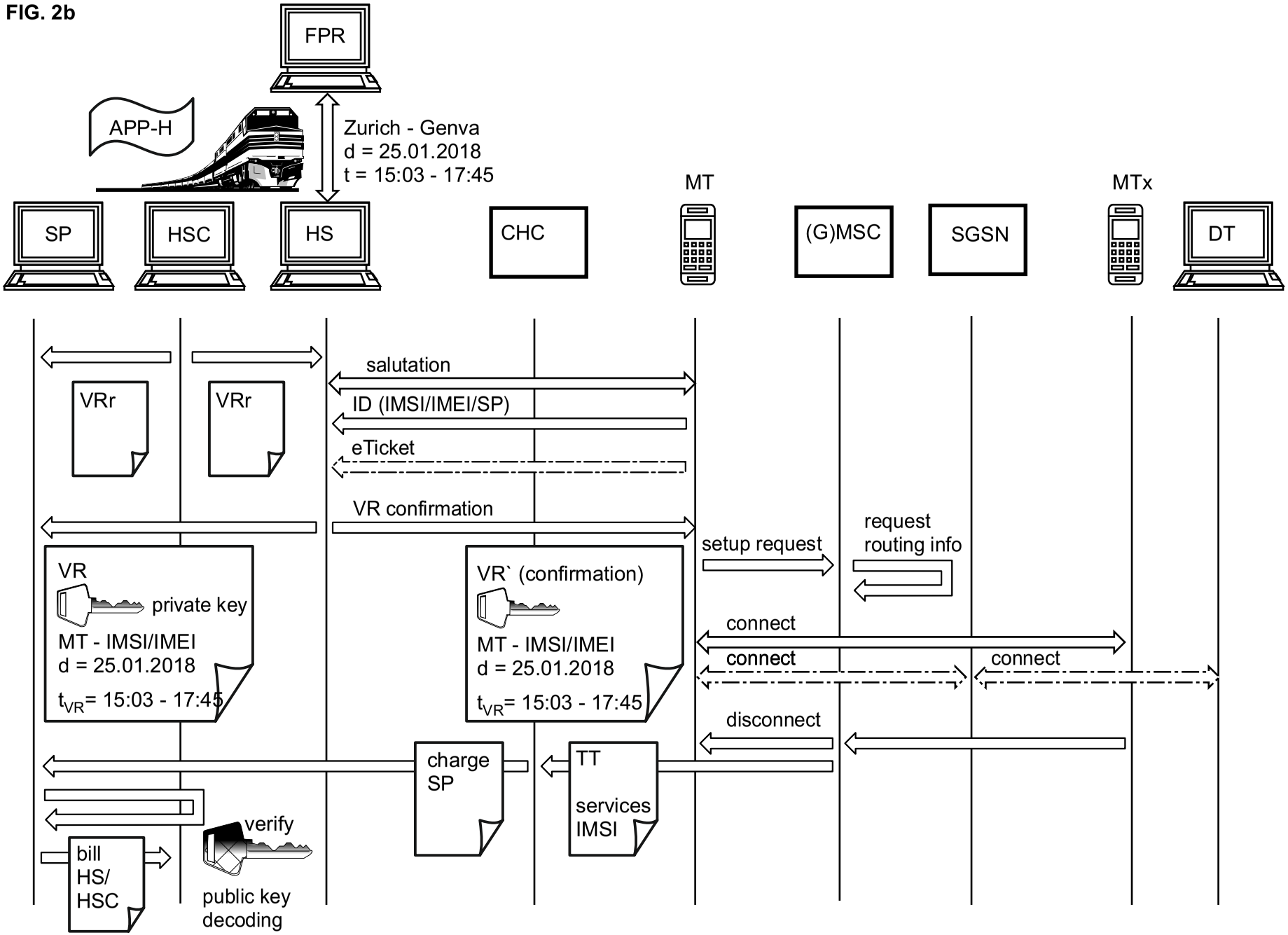

FPR
APP-H
Zurich - Genva
d = 25.01.2018
t = 15:03 - 17:45
SP
HSC
HS
CHC
MT
(G)MSC
SGSN
MTx
DT
VRr
VRr
salutation
ID (IMSI/IMEI/SP)
eTicket
VR confirmation
VR
private key
MT - IMSI/IMEI
d = 25.01.2018
t_{VR}= 15:03 - 17:45
VR` (confirmation)
MT - IMSI/IMEI
d = 25.01.2018
t_{VR}= 15:03 - 17:45
setup request
request
routing info
connect
connect
connect
disconnect
charge
SP
TT
services
IMSI
verify
bill
HS/
HSC
public key
decoding

FIG. 3a

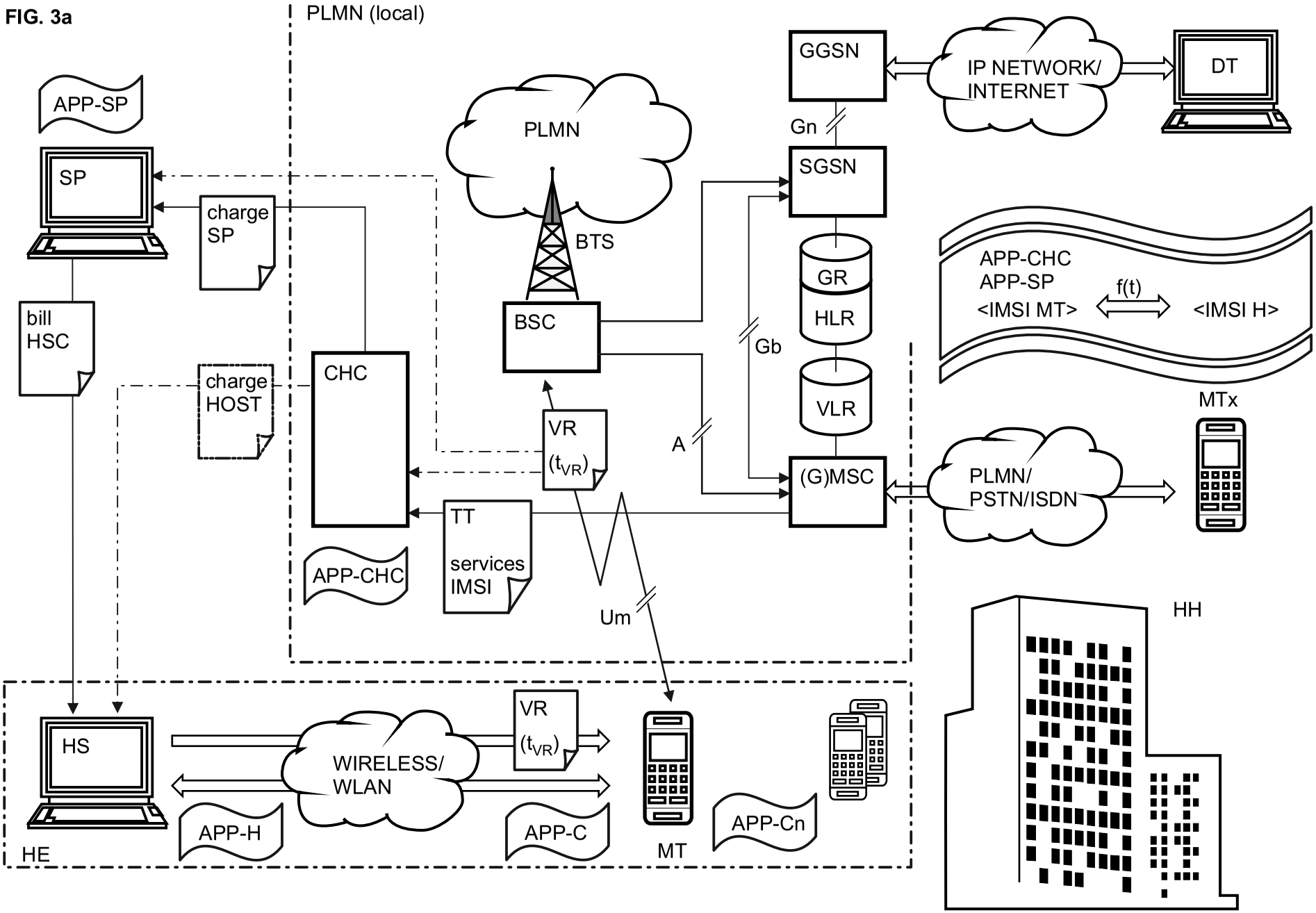

PLMN (local)
APP-SP
SP
charge SP
bill HSC
charge HOST
CHC
APP-CHC
TT
services IMSI
VR
(t_{VR})
PLMN
BTS
BSC
A
Gb
Um
GGSN
Gn
SGSN
GR
HLR
VLR
(G)MSC
IP NETWORK/ INTERNET
DT
APP-CHC
APP-SP
f(t)
<IMSI MT>
<IMSI H>
MTx
PLMN/ PSTN/ISDN
HH
HS
HE
WIRELESS/ WLAN
VR
(t_{VR})
APP-H
APP-C
MT
APP-Cn

FIG. 3b

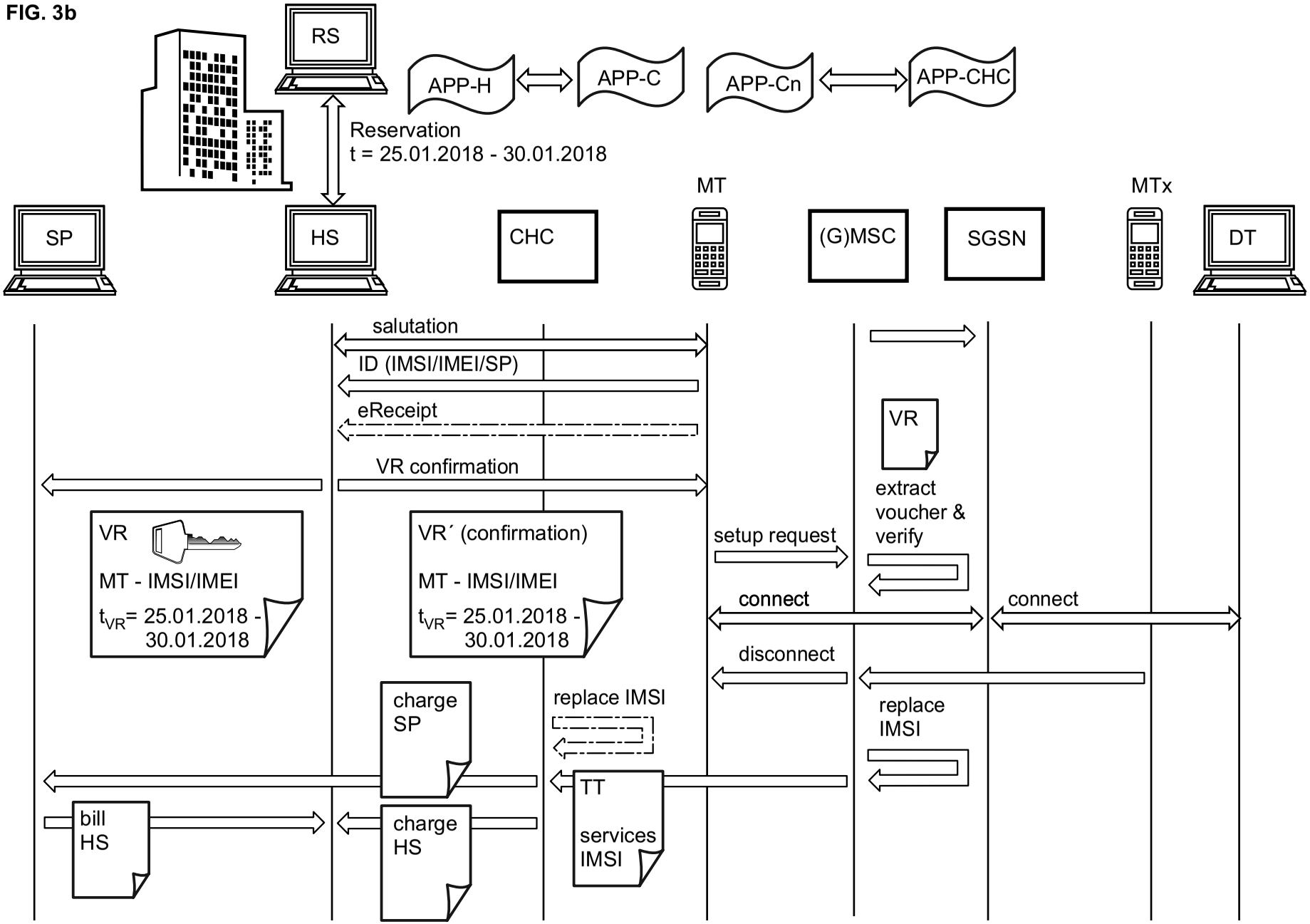

RS
APP-H
APP-C
APP-Cn
APP-CHC
Reservation
t = 25.01.2018 - 30.01.2018
SP
HS
CHC
MT
(G)MSC
SGSN
MTx
DT
salutation
ID (IMSI/IMEI/SP)
eReceipt
VR confirmation
VR
extract
voucher &
verify
VR
MT - IMSI/IMEI
t_{VR}= 25.01.2018 -
30.01.2018
VR´ (confirmation)
MT - IMSI/IMEI
t_{VR}= 25.01.2018 -
30.01.2018
setup request
connect
connect
disconnect
charge
SP
replace IMSI
replace
IMSI
TT
services
IMSI
bill
HS
charge
HS

Fig. 4a

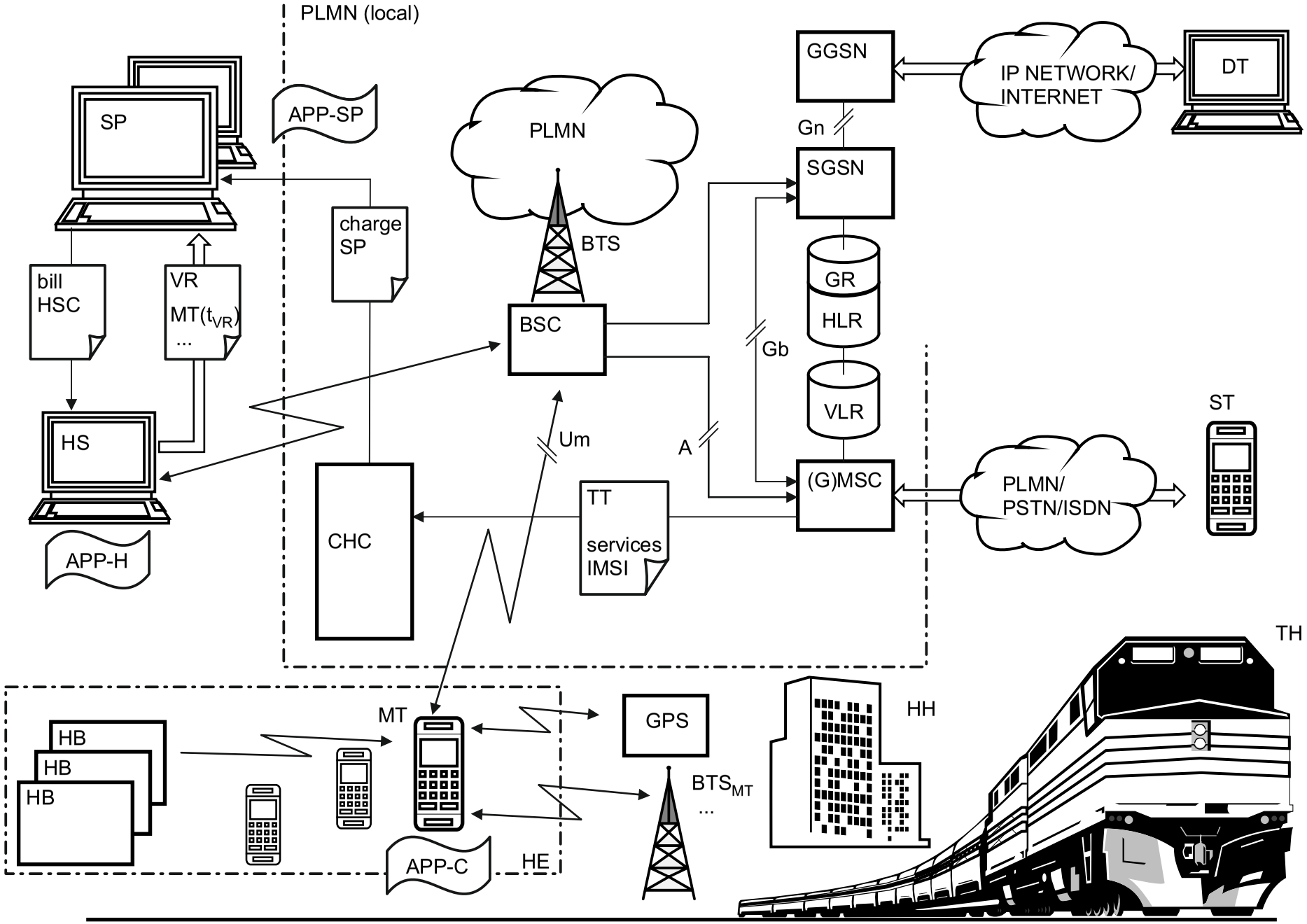
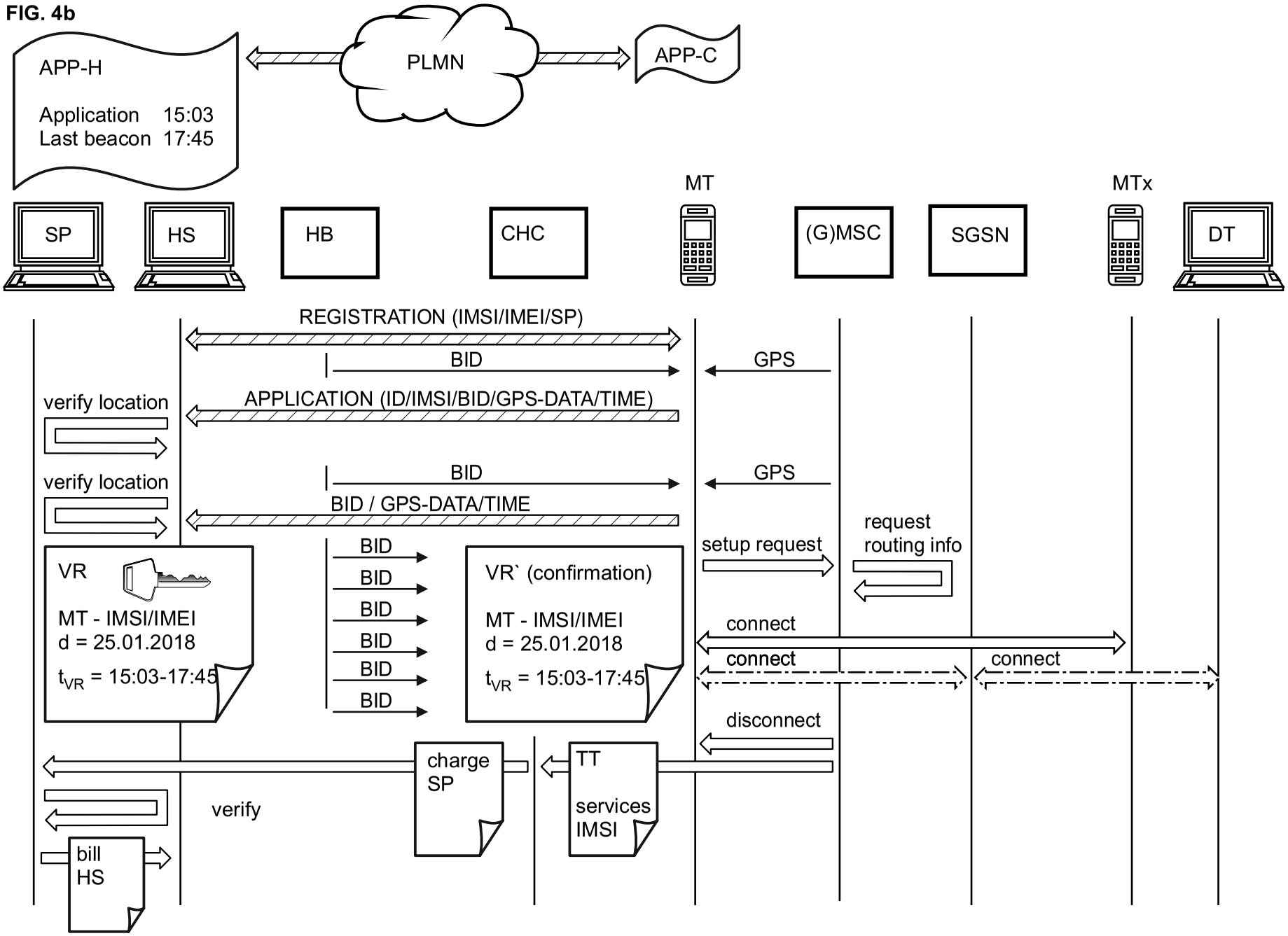

PLMN (local)
SP
APP-SP
charge SP
bill HSC
VR
MT(t_{VR})
...
HS
APP-H
CHC
PLMN
BTS
BSC
Um
A
Gb
Gn
GGSN
SGSN
GR
HLR
VLR
(G)MSC
TT
services IMSI
IP NETWORK/ INTERNET
DT
PLMN/ PSTN/ISDN
ST
TH
HH
GPS
BTS_{MT}
...
MT
HB
HB
HB
APP-C
HE

FIG. 4b


APP-H
Application 15:03
Last beacon 17:45
PLMN
APP-C
SP
HS
HB
CHC
MT
(G)MSC
SGSN
MTx
DT
REGISTRATION (IMSI/IMEI/SP)
BID
GPS
verify location
APPLICATION (ID/IMSI/BID/GPS-DATA/TIME)
verify location
BID
GPS
BID / GPS-DATA/TIME
VR
MT - IMSI/IMEI
d = 25.01.2018
t_{VR} = 15:03-17:45
BID
BID
BID
BID
BID
BID
VR` (confirmation)
MT - IMSI/IMEI
d = 25.01.2018
t_{VR} = 15:03-17:45
setup request
request
routing info
connect
connect
connect
disconnect
charge
SP
TT
services
IMSI
verify
bill
HS