GSM and IN Architecture
a common component: TCAP

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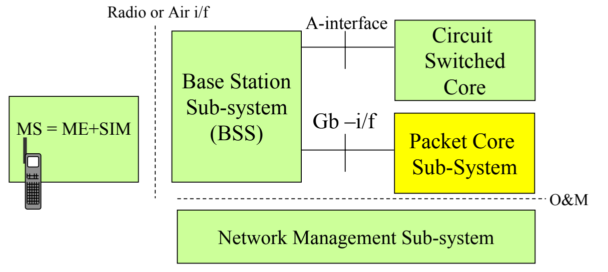
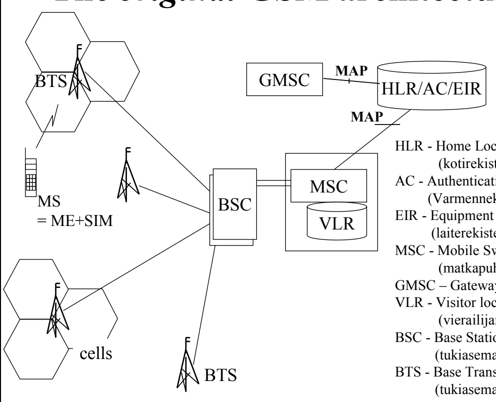
GSM system consists of sub-systems



MS - Mobile Station
ME - Mobile Equipment
SIM - Subscriber Identity Module
BSS - Base Station Subsystem
HLR belongs to both CS and PS domains

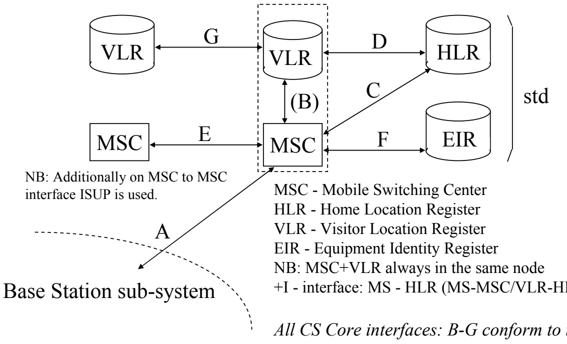
Main differences cmp to wire-line networks
- air interface for the subscribers
- mobility and roaming of users
NB: the whole system is digital incl the ME.

The *original* GSM architecture



HLR - Home Location Register (kotirekisteri)
AC - Authentication Center (Varmennekeskus)
EIR - Equipment Identity Register (laiterekisteri)
MSC - Mobile Switching Center (matkapuhelinkeskus)
GMSC – Gateway MSC
VLR - Visitor location Register (vierailijarekisteri)
BSC - Base Station Controller (tukiasemaohjain)
BTS - Base Transceiver Station (tukiasema)

CS Core interfaces are



NB: Additionally on MSC to MSC interface ISUP is used.

MSC - Mobile Switching Center
HLR - Home Location Register
VLR - Visitor Location Register
EIR - Equipment Identity Register
NB: MSC+VLR always in the same node
+I - interface: MS - HLR (MS-MSC/VLR-HLR)

All CS Core interfaces: B-G conform to the MAP protocol

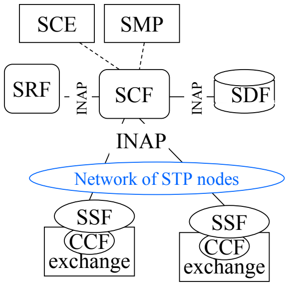
Business boundaries in GSM

- ✓ **Vendors and operators**
  - › **An operator can not just assume that all vendors conform to all interfaces that are found in GSM specs**
  - › **A-interface is firmly adhered to by all vendors: an operator can buy the cellular radio network from one vendor and the rest from another**
  - › **Also the Packet core is rather independent of the circuit network core – again two different vendors is a feasible alternative**
  - › **Advice: it is a good idea to buy HLR and MSC from the same vendor – if not two vendors may introduce features in a different order and the operator instead of getting the superset of features is getting the intersection of features.**
- ✓ **Mobile Virtual operators (MVO) of different types**
  - › **An MVO may but is not forced to have its own HLR**
  - › **The MVO HLR may need to work with MSC from a different vendor – not impossible**

CAMEL adapts the IN technology to GSM

- ✓ **CAMEL - Customized Application for Mobile network Enhanced Logic**
- ✓ **The goal is the capability of providing the home network services to visiting subscribers**
- ✓ **CAP - CAMEL Application Part is a subset of ETSI CoreINAP**
  - › **phases (Capability Sets) 1…4 are ready**

IN is a way of implementing services in nodes separate from exchanges



INAP = IN Application Part
= main protocol
CCF – Call Control Function
SSF - Service Switching Function
maintains call state with CCF
SCF - Service Control Function
implements service logic
SRF - Special Resource Function
processes in-band signals
SDF - Service Data Function
is a database
SCE - Service Creation Environment
for creating new service logic
SMP - Service Management Point
implements mgt functions

Features of the IN architecture ...

- ✓ **BCSM - Basic Call State Model is a standardized state machine in SSP - couples/ de-couples IN service logic from connection resources**
- ✓ **BCSM states (detection points) can be programmed to trigger queries on conditions to an SCF concerning a certain call**
- ✓ **BCSM architectural issue is that a call is also a service and therefore the architecture is service dependent**
- ✓ **INAP messages are independent of voice channel connections**

IN Application Part = INAP protocol

- ✓ **For signaling we use ISUP, TUP or whatever but for accessing service logic in SCF we use INAP**
- ✓ **When SSF detects a triggering point in a call (e.g. call coming from a certain circuit group and 4 digits have been dialled), it creates an INAP message to SCF bound to that triggering point.**
  - › **There are many different types of triggering points, they have been added into IN in different releases called Capability Sets.**
  - › **While SCF is doing its job, the exchange with SSF keeps the call "on hold" – keeps track of the resources used by the call maintaining call state.**
- ✓ **SCF returns instructions with INAP to SSF how to proceed with the call = how to change call state.**
  - › **SRF may be needed to receive more digits, play voice instructions to call parties, so SRF needs to be connected to the voice circuits at the exchange where SSF resides.**
  - › **What SRF has received, needs to be transferred to SCF for decision making**
- ✓ **When service logic has been applied, SCF drops itself from the call signaling path**

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Examples of subscriber services implemented using IN

- ✓ **Free call = A calls 0800-xxx-zzz number, B-party, e.g. some company trying to sell something pays for the call**
- ✓ **Primary rate service = a call to e.g. 0700-xxx-xxx. In addition to regular call charges, A pays additional charge e.g. 0,99€ per min**
- ✓ **Telephony VPN – a company uses public network to provide a PBX like service to its employees. The employees may have GSM/3G mobiles as terminals and use short numbers for internal calling. The VPN (or centrex) numbering plan is known to an SCF that implements the service. Company pays a flat rate for the service + there is a time based charge for outgoing calls. Internal calls are included in the flat rate.**

VPN –virtual private network

IN strengths and weaknesses

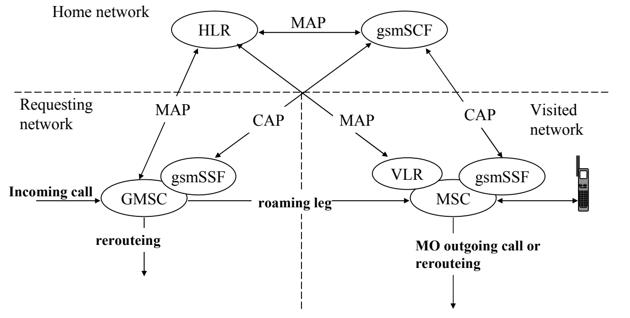
Strengths

- ✓ **Services e.g. for a company or new services can be implemented without changing software in all exchanges in a country (imagine the US)**
- ✓ **Quick service implementation using Service Creation Environment with a Graphical user interface within limits embedded in the systems and protocols**
- ✓ **Good at services that essentially need number translations + a bit of something else. E.g. Free calls and premium rate calls and telephony VPNs.**

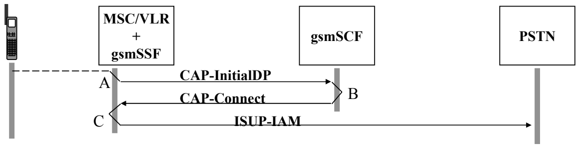
Weaknesses

- ✓ **BCSM assumes that a call can be modeled once and for all. We have two different protocols, one for signaling such as ISUP and INAP and BCSM coupling the two. It would be much more straightforward to be able to route signaling for a call fulfilling certain conditions to a particular server and apply whatever logic is needed.**
- ✓ **IN assumes that a lot of value can be captured by adding tricks to call processing. (Free calls have been a money maker in the US).**
- ✓ **Many Capability Sets (=releases) of IN specs were needed before "sufficient" features were in place**

Phase 1 CAMEL architecture



MS originated CAMEL call



A - MSC gets the CAMEL service info from the VLR concerning the A subscriber, sees an active CAMEL service and hands the call to gsmSSF. gsmSSF queries gsmSCF:lle (service key, A-nr, B-nr, IMSI, location...

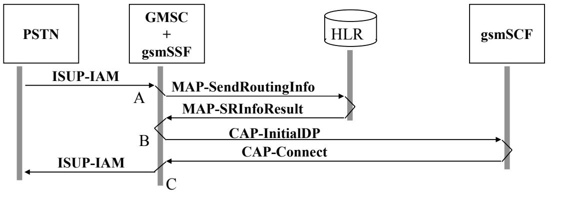
B - gsmSCF can for example do a number translation

C - MSC sets up a call using the received info

DP – detection point

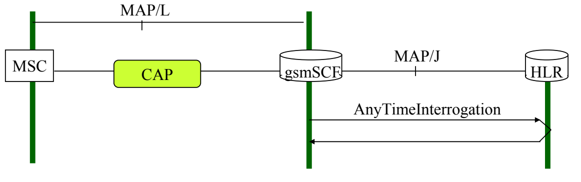
NB: The the service for the visiting subscriber is executed cooperatively by the visited network (MSC/VLR) and the home network! → Home network is not autonomous in providing the service!

Mobile terminated CAMEL call



A - GMSC queries HLR of the location of the MS. HLR sends the terminating CAMEL service data of the subscriber.
B - GMSC hands the call to gsmSSF, which queries gsmSCF gsmSCF returns C-number that is used for routeing the call
C - GMSC sets up the call to C-number. If needed, GMSC can first do a new HLR query.

An SCF can interrogate HLR at any time



IN+GSM integration based on CAMEL is a step towards 3G

- ✓ **CAPv1 supports only 7 operations**
- ✓ **CAPv1 call model has only a few triggering points (TDP - trigger detection point)**
- ✓ **CAPv2 has 22 operations**
- ✓ **Still no triggering for Short Messages**
- ✓ **CAMEL compatible equipment is in use in many networks**
- ✓ **http://www.3gpp.org/TB/CN/CN2/camel-contents.htm contains an overview of CAMEL phases 1 to 4.**

Need to separate application logic states from communication states is common to IN and MAP

- ✓ **IN application is concerned with the end user service, its implementation may be broken into several modules each with its own communication needs between SCP and SSP.**
- ✓ **HLR and MSC may be discussing about a handover, VLR update etc in the same context – each part of MAP has its own communication needs.**
- ✓ **It makes sense to have a common component between the application and SCCP that will provide services friendly for applications and take care of communicating with the other part of the application in a remote node (HLR, VLR, MSC, SCP, SSP etc)**

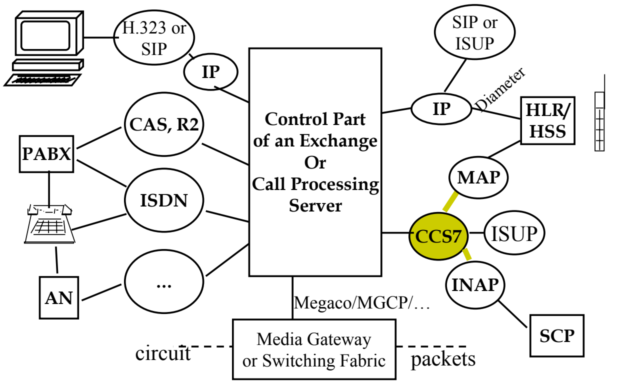
TCAP - Transaction Capabilities Application Part is used by

- ✓ **Mobile services (roaming and mobility management)**
- ✓ **Intelligent Network services**
- ✓ **Services that are independent of voice circuits (look-ahead …)**
- ✓ **O&M applications**
- ✓ **etc**

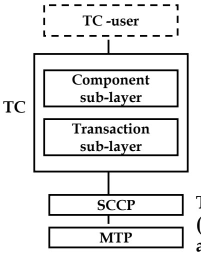
TCAP provides generic services supporting the execution of distributed transactions.
Parties in the transactions can be exchanges, service nodes, data bases etc.

TCAP offers a way to implement services that are independent of network resources.

Summary of course scope



TCAP has two sub-layers



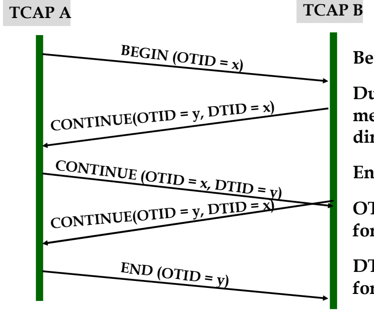
Component sub-layer: data units of the application protocol, requests and responses, dialogues: application context

Transaction sub-layer: message exchange between parties, optionally dialogues between parties.

TCAP has a lot of similarity with ROSE (Remote Operation Service Element) and ACSE (Association Control Service Element). ROSE ja ACSE are OSI layer 7 services.

Transactions are sequences of events that allow to read or write some data entry or entries in a remote network node.

A TCAP use case



Begin begins a dialogue

During the dialogue Continue - messages are sent in both directions.

End-message closes the dialogue.

OTID -identifies the dialogue/ for the sender of the transaction.

DTID -identifies dialogue/ for the object of the transaction.

TCAP supports four operation types

- ✓ **Class 1 - Both success and failure are reported**
- ✓ **Class 2 - Only failures are reported.**
- ✓ **Class 3 - Only success is reported.**
- ✓ **Class 4 - Nothing is reported**

An operation is identified by the Invoke-Id - identifier.

Indication (ind) is associated with the request (req) based on the Invoke-id.

A user may have many ongoing active operations simultaneously.

TCAP is a purely end-to-end function. There may be many inter-mediate nodes in the CCS7 network that do not touch TCAP.

Operations are identified and chained using the Invoke-Id

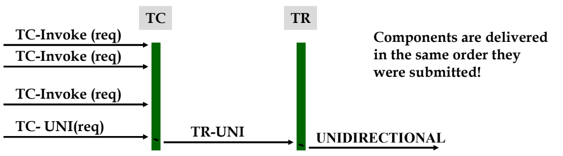
- ✓ **Operation is identified by the Invoke-Id.**
- ✓ **Indication (ind) is associated with the request (req) based on the Invoke-id.**
- ✓ **The Response can be a new operation request that is chained to the previous operation request using a link-identifier.**
- ✓ **A user may have many simultaneous operations.**

The result of an operation sent to a remote system can be

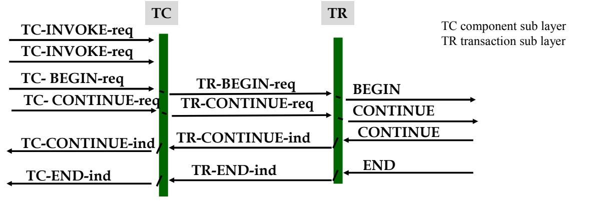
- ✓ **Result: Operation succeeded.**
  - › **The result can also be segmented (chained)**
- ✓ **Error: Operation failed.**
- ✓ **Reject: Execution of the operation is not possible.**
- ✓ **Before sending the result, the remote system can send an arbitrary number of linked operations.**

Non-structured dialogue transfers one or more components

- ✓ TC-user can send many components in Class 4 operations by a UNIDIRECTIONAL message.
- ✓ Components with the same dialogue -id can be sent in one message.
- ✓ Control over sequencing of operations is left to the application.

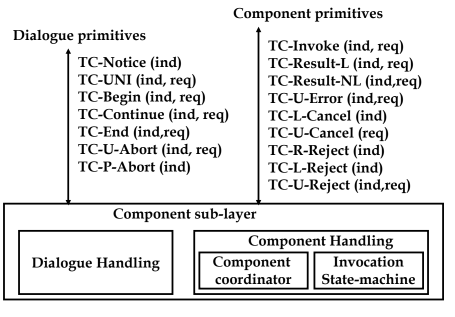


A Structured dialogue has a beginning, information transfer, ending or abort



- Begin causes a *transaction identifier* to be reserved.
- The remote system can either continue the transaction or close it.
- Continue - messages are exchanged in a full-duplex mode.
- Closing options:
  - based on pre-arrangement independently
  - normally by the End-message or "abnormally" by an Abort message

The Component sub-layer is split into dialogue handling and component handling



Component handling primitives are

TC_INVOKE - Invocation of an operation which may be linked to another operation

TC_RESULT_L - Only result or last part of segmented result of a successful operation

TC_RESULT_NL - non-last part of segmented result

TC_U_ERROR - reply to a previously invoked op that failed

TC_L_CANCEL - informs user of local timeout

TC_U_CANCEL - Causes local termination of op on TC_user request

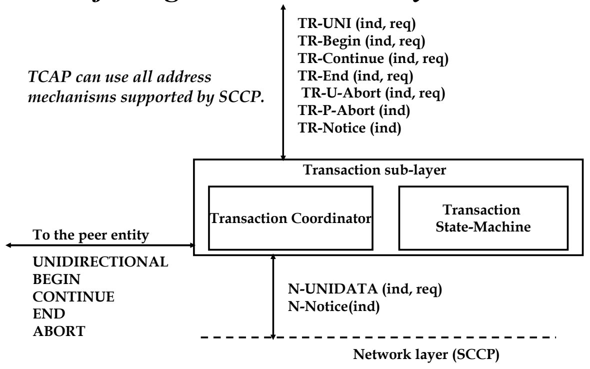
TC_L_REJECT - local reject by Component sub-layer to TC_user

TC_R_REJECT - remote reject by remote component sub-layer

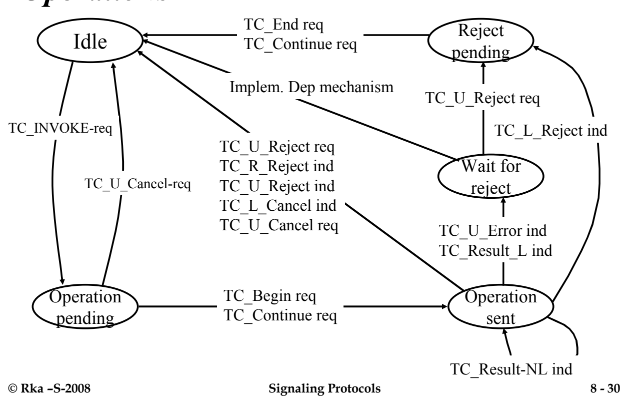
TC_U_REJECT - Rejection by TC_user indicating malformation

Transaction sub-layer handles the interfacing to the network layer

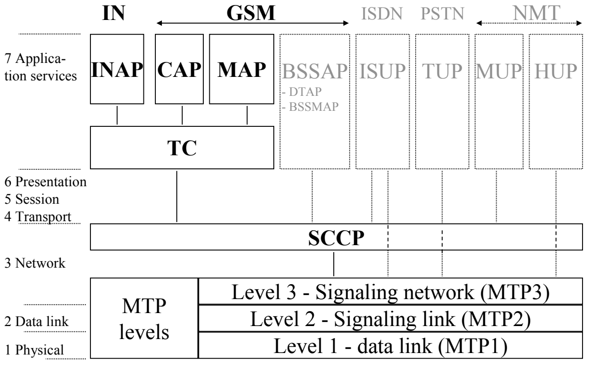
TCAP can use all address mechanisms supported by SCCP.



State transition Diagram for Class 1 Operations



Most important users of TCAP are..



Summary: TCAP added value is

- ✓ **Decoupling the actions and states of an application from communication states for managing the flow of information with the remote end**
- ✓ **Takes care of managing the communication with the peer – lets the application concentrate on essential matters**
  - › **four classes of service**
  - › **report on success tells the application that the remote end has done its job for sure**
  - › **report on failures speeds up recovery (but an application can not really rely on getting the report on every failure!)**
  - › **or alternatively can let the application take care of all acknowledgements**