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Performance Evaluation of IN based Mobility Management

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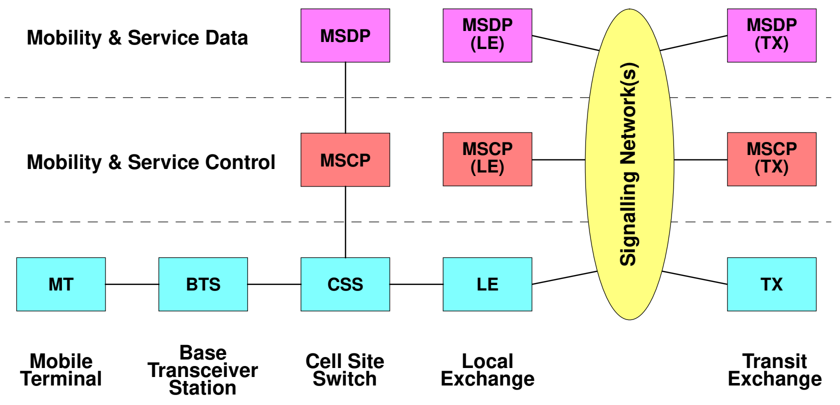
Outline

- Introduction
- Modelling Approach
- Planning Tool Concept
- Analytical Approach
- Mobility Management
- Case Study

Abbreviations: BTS - Base Transceiver Station; CCAF - Call Control Agent Function; CCF - Call Control Function; CS - Capability Set; CSS - Cell Site Switch; FE - Functional Entity; FEA - Functional Entity Action; IN - Intelligent Network; INAP - Intelligent Network Application Part; IP - Intelligent Peripheral; ISDN - Integrated Services Digital Network; ISUP - ISDN User Part; LE - Local Exchange; MSCP - Mobility&Service Control Point; MSDP - Mobility&Service Data Point; MT - Mobile Terminal; MTP - Message Transfer Part; PE - Physical Entity; POI - Point of Inititiation; POR - Point of Return; PSTN - Public Switched Telephone Network; PLMN - Public Land Mobile Network; SCCP - Signalling Connection Control Part; SCF - Service Control Function; SCP - Service Control Point; SDF - Service Data Function; SDP - Service Data Point; SIB - Service Independent Building Block; SP - Signalling Point; SRF - Specialized Resource Function; SS7 - Signalling System No.7; SSF - Service Switching Function; SSP - Service Switching Point; STP - Signalling Transfer Point; TCAP - Transaction Capabilities Application Part; TX - Transit Exchange; UMTS - Universal Mobile Telecommunication System; UPT - Universal Personal Telecommunication

Introduction

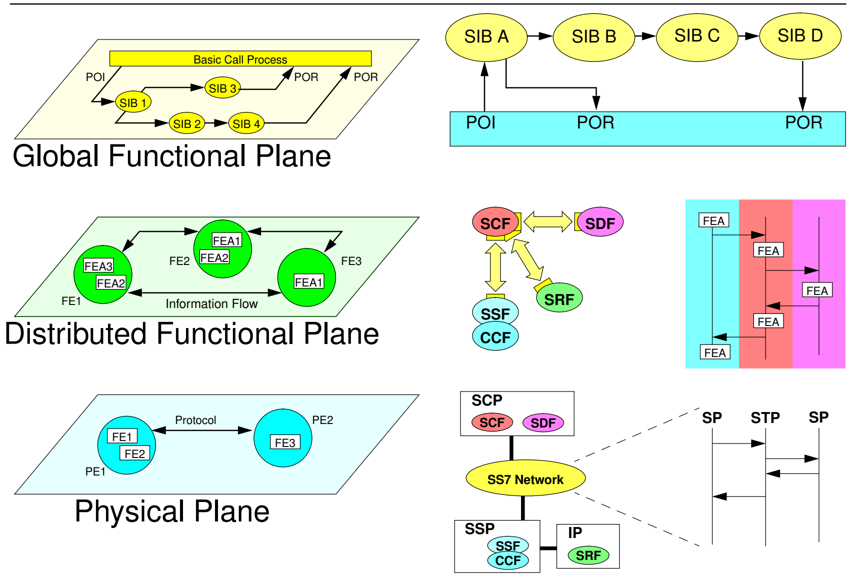


Possible Network Architecture of UMTS

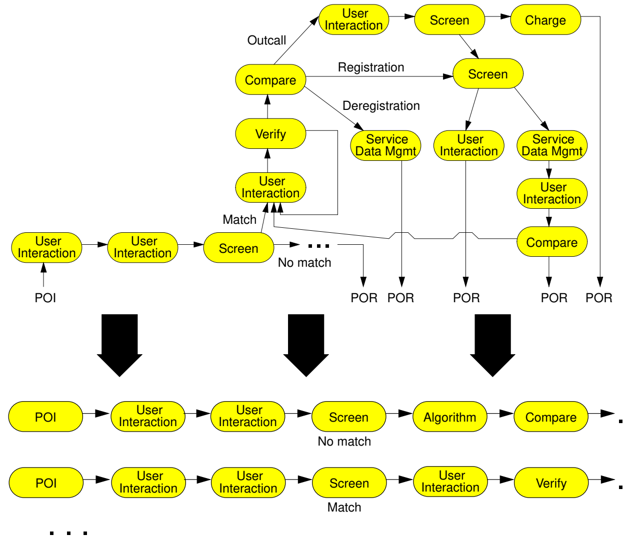
Concepts for mobility management in Universal Personal Telecommunication (UPT) and in third generation mobile communication systems (like e.g. UMTS) heavily rely upon Intelligent Network (IN) concepts and infrastructure. In fact, mobility management can be viewed as just another IN service.

The necessity to have network performance and capacity figures available arises in a variety of situations, ranging from planning telecommunication networks from scratch to introducing new services into existing networks which may or may not already provide IN-based services. It is important to properly consider the IN as an integrated part of a telecommunication network, since the additional load generated by new IN services may lead to a performance degradation that can spread beyond the IN environment and may affect not only new and existing IN services, but also basic services offered by the network. In particular, the common channel signalling system and IN physical entities are systems where services may affect the performance of each other.

Modelling Approach



Linearization of Service Logic Description



We present a hierarchical modelling approach where the load generated by new (mobility) services on the signalling system and on the IN physical entities is derived from the service description on the global functional plane of the IN conceptual model. This is done in several steps including the derivation of service scenarios from the service description, the linearization and the refinement of service logic, and the mapping onto the different planes of the IN conceptual model, resulting in a signalling message flow and functional entity actions in physical entities of the signalling network and the IN.

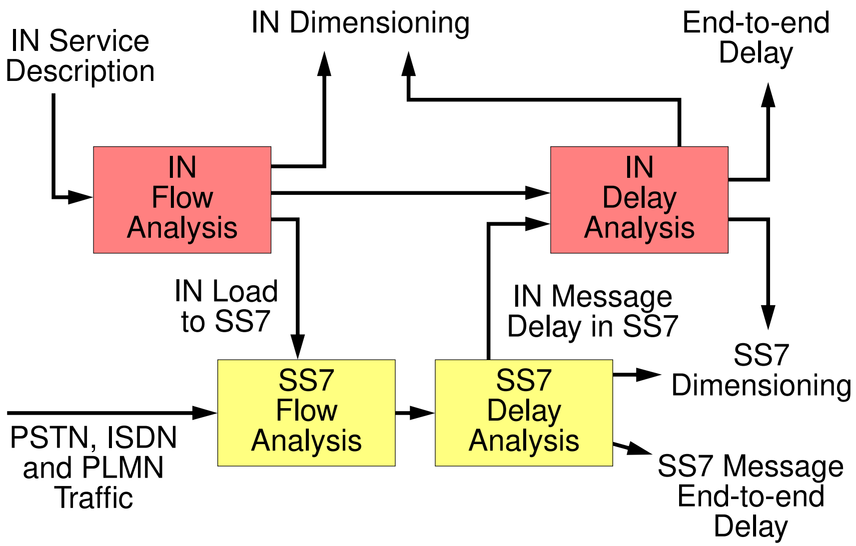
In this contribution, only the case only the Signalling System No. 7 (SS7) as the supporting protocol is considered. Special care has to be taken in modelling user behaviour and in considering addressing capabilities of the signalling system like e.g. Global Title Translation in SS7.

The basic components of IN service definitions are the SIBs. A SIB can result in distinct information flows in the physical plane. The information which SIB is executed is usually not sufficient. A SIB can result in very different information flows depending on several factors. Therefore a more detailed view of the SIBs must be taken into consideration.

All the possible combinations for the input and the possible results of a SIB are identified and isolated as a new element denominated sub-SIB. The objective of the sub-SIB is to cater for the set of combinations which influence global network performance.

A new service is defined as a chain of these sub-SIBs. Generally, the service logic depends on decision events, and consequently the chain of sub-SIBs results in a complex structure. For the tool purpose, all possible paths are represented linearly in scenarios of the service logic.

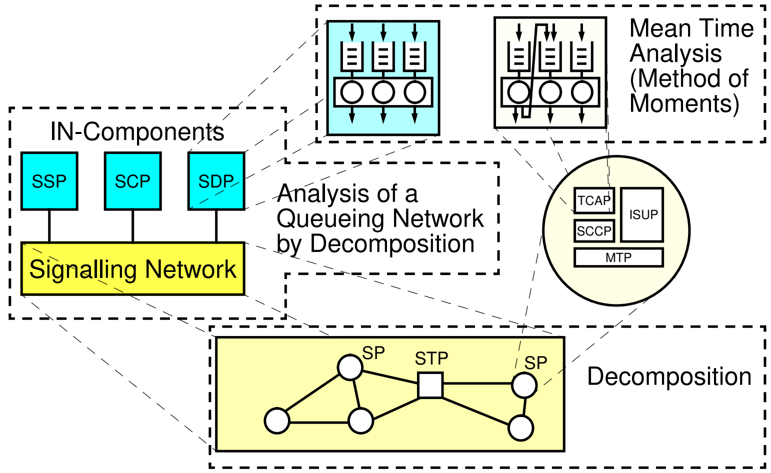
Planning Tool Concept



The development of a tool concept for the IN must be able to take into consideration the integration of the IN in a telecommunication environment. The IN shares the signalling network capabilities with a variety of services, e.g. PSTN, ISDN, PLMN, etc., and the resulting traffic mix must be considered in the analysis. Previous work concerning the development of a performance evaluation tool for the signalling network has already been done. Therefore the IN performance analysis tool was implemented as a modular extension of an existing tool for the signalling network.

The planning tool execution is carried out in four steps: In the first step, a flow analysis is done for the Intelligent Network which yields the load on the physical entities and the exchange of signalling messages. In the second step, a flow analysis is done for the signalling network, taking into consideration additional traffic from e.g. ISDN. This yields load on the elements of the SS7 (SPs, links). In step three, an SS7 delay analysis is done, whose results are used in step four to perform an IN delay analysis.

Analytical Approach

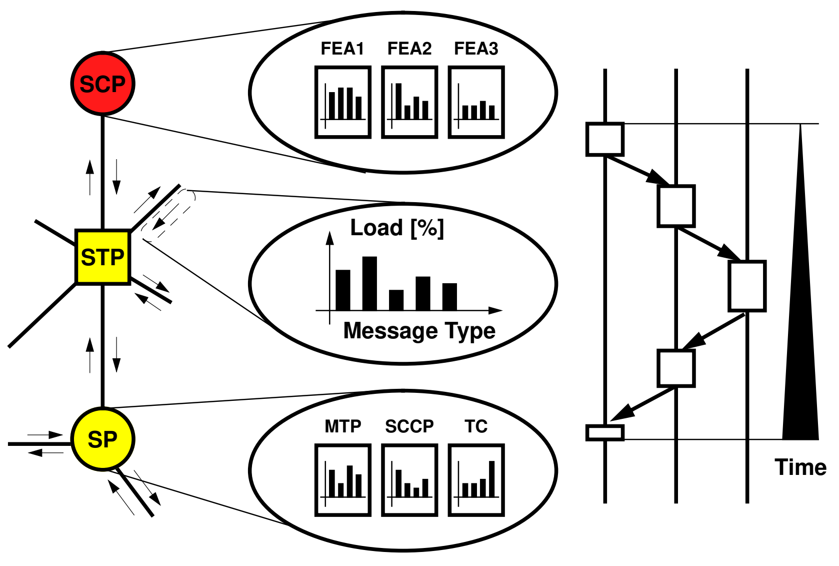


The Performance analysis is conducted using hierarchical decomposition techniques, allowing a detailed consideration of the applied protocols and the (vendor- specific) implementation of physical entities in the network.

IN infrastructure and the signalling network are analysed separately. The protocols of the signalling system are modelled in a very detailed manner, which results in processor models with priorities, feedbacks and forking of messages. After decomposition, a mean delay analysis of those models can be done by using the methods of moments.

The results obtained from the signalling network analysis are returned to the IN model. Here, the signalling network corresponds to an infinite server with the obtained mean delay time for each message type. The IN network is analysed by considering the system as a multiple-chain queueing network with individual service times. The results yield the mean time required for every particular operation.

Obtainable Results



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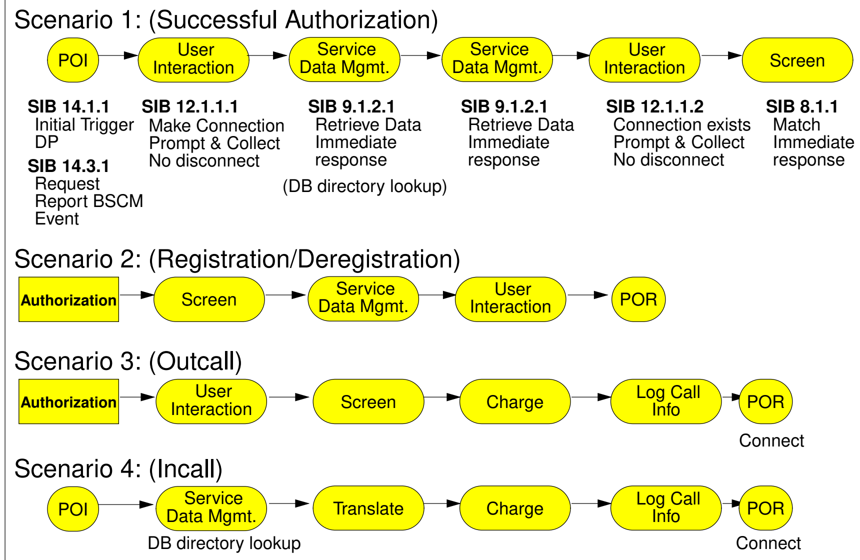
The results of the analysis include service- and protocol-specific loading of network entities like signalling links, signalling protocol processors and IN physical entities, delay of specific messages in the signalling network and in IN nodes, and service-specific grade of service criteria like e.g. mean post-selection delay.

These results allow to evaluate the performance of newly deployed services, including their impact on the telecommunication network and on the performance of the services already offered. This information supports dimensioning of the signalling network and the IN elements according to a given service mix and traffic figures. Furthermore, it helps to compare different implementation strategies for the IN infrastructure.

Some Mobility Management Scenarios



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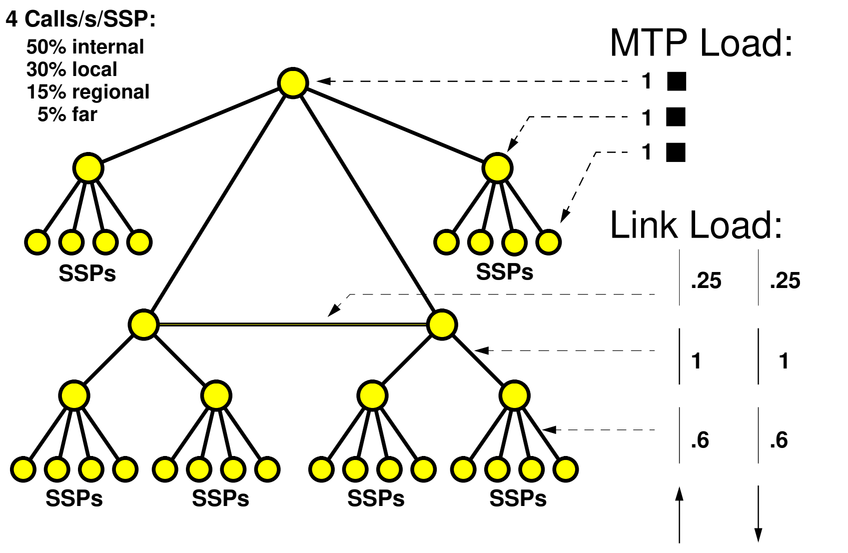
As an example, some mobility management scenarios are shown. The scenario Successful Authorization is presented in detail, including the denomination of all sub-SIBs. At the point of initiation, two sub-SIBs are used which result in a message flow between SSF and SCF: A InitialDP is sent from SSF to SCF where service logic is invoked. In return a RequestReportBCSMEvent is sent from SCF to SSF to request CCF/SSF to report call abandoning by the user, in order to terminate SCF processing. Then the user is requested to identify himself. This is done by means of the sub-SIB User Interaction with Establishment of a Connection to Resource, with Prompting and Collection of Data and without a Disconnect of the Connection to Resource. This results in a message flow which includes ConnectToResource, PromptAndCollectUserInformation and CollectedUserInformation. Then the home database of the user is requested from the database directory and an authentication vector is retrieved from the home data base of the user. Usually different SDFs are involved here. Eventually, the user is prompted to authenticate himself and the correctness of the result is used for screening.
Scenarios like Registration, Deregistration, Unsuccessful Authentication, Outcall and Incall have been specified in the same way.

Case Study: ISDN



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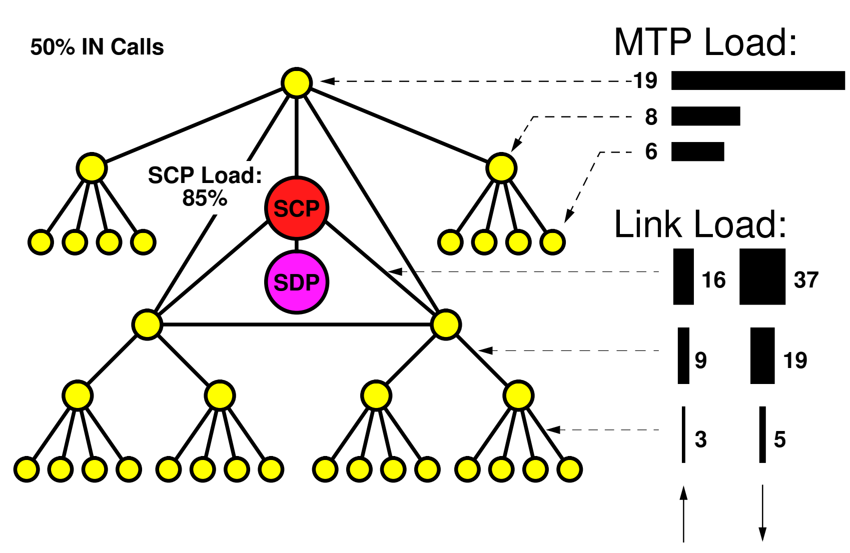
In order to provide an overview of the application of the modelling concept, a (hypothetical) case study is provided. As a starting point, we look at a network providing usual ISDN services. The network is structured hierarchically. 24 local exchanges are origin and destination of ordinary ISDN calls. A traffic distribution is assumed where 50% of the calls are handled within one exchange, 30% via one transit exchange, 15% via three transit exchanges, and 5% via four transit exchanges. We assume a powerful signalling network infrastructure which is able to cope easily with the offered signalling traffic assuming 4 calls/s from each local exchange (SSP).

In order to be able to compare the load on the network in this case to the load in the network with mobility management, we normalize the current load in the MTP of each signalling point to one and the load on the signalling link sets with the load on the link set which is the most heavily loaded.

Architecture I: Centralized SCP/SDP



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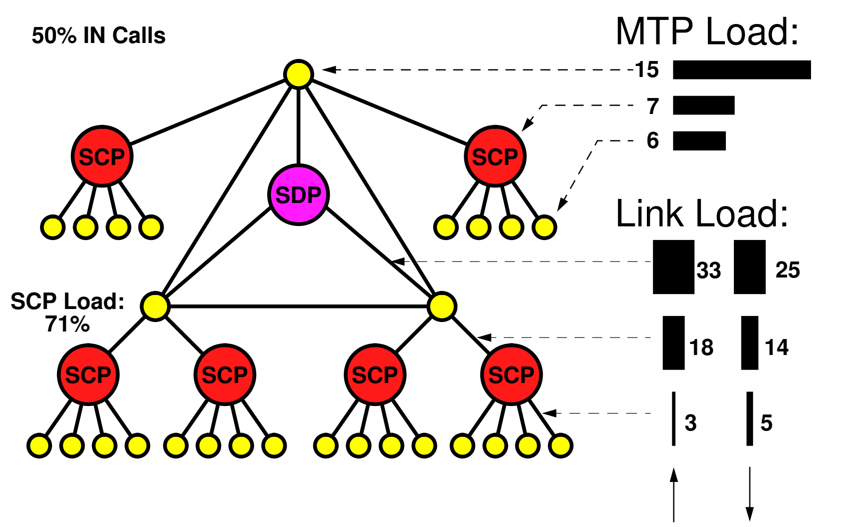
We introduce a UPT-like service with mobility management. All local exchanges can act as Service Switching Points. We add a centralized SCP which is connected via a high speed link to an SDP.

We assume that 50% of the calls activate outcall service logic, that 50% of the calls invoke incall service logic, and that for each call 0.5 Registrations and 0.5 Deregistrations are performed.

IN flow analysis yields an SCP Load of 85%. SS7 flow analysis yields an MTP load which is up to 19 times larger than in the network without the IN service and a link set load which is up to 37 times larger than the link set load of the most heavily loaded link set in the network without the IN service. The link load is asymmetric. Links from SSPs to SCP are more loaded than links in the opposite direction. Furthermore large processing capacity is needed to handle SCCP an TCAP processes.

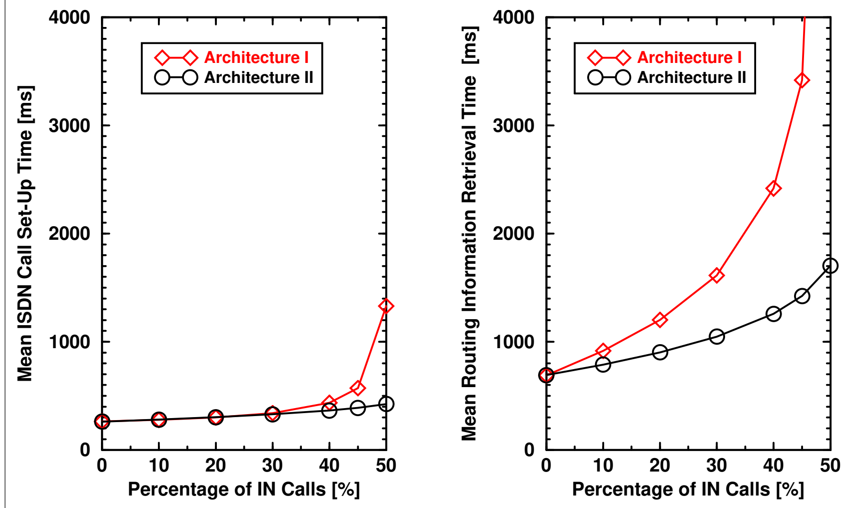
Architecture II: 6 small SCPs & 1 centralized SDP



An alternative architecture is composed of six small SCPs (a fifth of the size of the centralized SCP) which are placed closer to the SSPs. We still keep a centralized SDP which stores user data like authentication keys and location information.

IN flow analysis yields an SCP load of 71% for each of the SCPs. Since message flow between SCPs and SDP is very intense, the load of the signalling system does not differ fundamentally from the load in architecture I. SS7 flow analysis yields an MTP load which is up to 15 times larger than in the network without the IN service and a link set load which is up to 33 times larger than the link set load of the most heavily loaded link set in the network without the IN service. Once again the link load is asymmetric. Here, links from the SDP to the SCPs are more loaded than links in the opposite direction.

Results of Delay Analysis



Although the load analysis did not show a fundamental difference between the two network architectures, the delay analysis does show some differences. The two figures illustrate the impact of the introduction of the new IN service on the call set-up time of ordinary ISDN calls and on the routing information retrieval time for incoming calls to subscribers of the UPT-like service. The percentage of IN calls (or subscribers) varies from 0% to 50%.

Figure 1 shows that ISDN call set-up time is only slightly affected by the introduction of the new service, except for the case of 50% penetration in architecture I. The reason for this influence is a very heavy load in the second transit exchange (19 times larger than in the network without the IN service). Architecture II is by far less affected, because the load in the second transit exchange is only 15 times larger than in the network without the IN service.

Routing Information Retrieval Time for 50% penetration in architecture I is intolerably high. This is due to the heavy loading of the SCP and the heavy MTP load in the second transit exchange. Architecture II on the other hand performs reasonably well.