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# Towards seamless control and management systems

*F. J-P. Dupuy*

*France Télécom BD/CNET*

*2 Avenue de Pierre Marzin*
*Technopole Anticipa*
*22300 Lannion*
*FRANCE*
*tel: 33 2 96 05 36 65*
*fax: 33 2 96 05 37 84*
e-mail: dupuy@lannion.cnet.fr

**Abstract**

The control and management services add new value to the telecommunications networks. As these services evolve, due to various factors like an increasing network technology diversity, increasing processing capabilities at the public periphery and reglementary acts, two trends can be observed : an externalization of the intelligence and the absence of a common technical approach between the public and private control and management systems.
The objectives of this paper are to give a short state of the art of the control and management systems (intelligent networks, computer-telephony integration servers, Internet) and to highlight the benefits that would be gained by interconnecting them (i.e. providing more 'seamlessness' and building a global information network). Once the advantages explained, the paper lists the requirements that can be anticipated on this global and seamless control and management system : fine identification of the information flows, independence of the platform providers, deployment flexibility, system reusability. In order to solve most of these requirements, the telecommunication community should now agree upon a single, generic enough, software architecture.
As explained brievely in this paper, TINA proves to be a good candidate, provided that more global effort is spent on its assessment and validation.

**Keywords**

Distributed network control systems, intelligent networks, TINA

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## 1 INTRODUCTION

Control and management represent indeniably very crucial functions in telecommunications networks. Controlling a telecommunication resource aims at using it, immediately or lately, for a limited period of time or not, whereas managing a resource corresponds to operations ensuring its availability, configuration validity, performance, accounting, etc.
Three elements, at least, that impel the current control and management systems to evolve can be identified. The first one is that the telecommunication resources keep on increasing and varying both in the public and private networks : wireless access networks, multiplexing systems and hubs, cell or frame switching systems, external processing servers, etc. This steady diversification suggests to rationalize and harmonize the way to control and manage all these resources in order to lower the global network cost (and to get economies of scale).
The second element is the increase of processing capabilities at the public network periphery and consequently the emergence of control and management functions 'outside' these public networks. Not surprisingly, but still regrettably, the solutions chosen for providing control and management systems in the public or private networks rely on the same principles - intelligent processing units external to the tranport network - but are technically different. The evolution of the public networks is mainly taken over by the telecommunications standard bodies (ANSI, ETSI, UIT-T) or by consortia like TINA-C[1], whereas that of the private networks is taken over by the computer and private telecommunications equipment manufacturers (ECTF[2], ECMA[3], Novell, Microsoft). Thus very similar control and management functions, like call processing, signal processing, network management, service control, are now available both in the public networks (Intelligent Networks, Telecommunication Management Networks) and in the customer premises equipments (Microsoft TAPI, JTAPI to-be, PABX and CTI[4] servers, Intranet). And no continuity (neither logical nor physical) exists between the two kinds.

[1]. Telecommunication Information Networking Architecture Consortium

[2]. Enterprise Computer Telephony Forum

[3]. European Computer Manufacture's Association

[4]. Computer Telephony Integration

There is actually no seam at all - in the proper sense - between the two types of control and management systems, no direct interworking, although, as shown in this paper, it would provide new service features.

Lastly, the third element of evolution could be the reglementary decisions, like the ones aiming at opening the networks amd having them interconnected. Since the control and management systems are more and more externalized, openness is likely to be required at two interface levels, at the resource control and management interface between the processing servers and the transport network equipments on one hand, at the interoperability interface between the various control and management systems[5] on the other hand.
This paper describes why an evolvement of the actual control and management systems towards more open and distributed processing systems (e.g. TINA-like systems) is necessary and what it actually means and implies.

## 2 THE TELECOMMUNICATIONS RESOURCES TO CONTROL AND MANAGE

In order to illustrate the constant increase of the telecommunication resource diversity, the usual layer model is used. The first telecommunication resource layer corresponds to the transmission infrastructures, subdivided into the access networks and the transmission networks. The resources of this layer provide the support for transporting informations, this support being either a cupper pair, a cable, an optical fiber or an electromagnetic field. New transmission techniques have emerged these last years, like the Synchronous Digital Hierarchical transmission for the transmission networks, FDMA/TDMA , Asynchronous Digital Subscriber Lines, or Digital European Cordless Telephony for the access networks.
The second telecommunication resource layer is called the transport layer and relies on the transmission infrastructures. It provides OSI level 2 links and OSI level 3 network channels and includes 64 kbit/s telephony circuits, X.25 virtual circuits, IP datagrams, frame relay, cell switching, etc. The newness here is embodied by new IP routing protocols (I-PNNI), frame or tag switching in the local networks, packet radio services (GPRS) over GSM networks, ATM, etc.
The third layer is characterized by information storage and processing servers, connected to the (private or public) telecommunications networks as end-points : (domain) naming servers, vocal or electronic mail boxes, intelligent peripherals

[5]. Needless to say that the second level is more acceptable, because more secure.

(DTMF detection, interactive voice response, voice processing), information caching servers, information servers (WWW, VoD).
There is no sense, of course, in aiming at a single control and management system for all theses resources. There are nevertheless reasons for targetting more interworking between the different (control and management) systems : it can help to provide new control and management services and consequently to satisfy end-users , to optimize the transport network usage, to reduce its load, and possibly to reduce the network and service development costs.

# 2. TOWARDS SEAMLESS CONTROL AND MANAGEMENT SYSTEMS

## 2.1 Control and management systems, as information networks

Control and management of network resources or end-user telecommunications services can be called telecommunications global intelligence: they necessitate information processing and storage at various computing nodes (e.g. Service Control Points, Operations Systems, ...) and information transmission between these nodes (inband, outband on SS7 or X.25 networks). Therefore, control and management systems are real information networks, as TINA-C is actually considering them (Dupuy, 1995) (Rubin, 1994).

Compared to the protocol reference model (ITU-T I.320 Recommendation), a perception inversion has nevertheless to be operated : these control and management systems should be considered less and less as logical resources associated with the switching systems, but as value-added networks served by switching or transmission equipments. The same analogy, as that suggested in (Buckley, 1995) for the universal signalling network concept, can apply : control and management systems are comparable with computers and the transport networks with peripheral devices.

## 2.2 Private and public information networks

The control and management systems deployed until now by the public telecommunications operators are different in nature and rarely interconnected one to the others : a IN service control point interconnected to a service data server or to a service management point by SS7 networks represents an example of a control-oriented information network; the future CAMEL systems or the SS7 network interconnection of Home Location Repositories and Mobile Service Centers represent other control-oriented information networks.

Telecommunication Management Networks are obviously management-oriented information networks. As a matter of fact, the current trend, as embodied by the information networks referred to above, is to more and more externalize the control and management services, out of the transport network equipments, in order to shorten the service development cycle and to unbind these services from the equipment technology: the information networks tend to be logically and physically separated from the transport networks.

Internet represents another public control-oriented and management-oriented information network: it allows to control the delivery of a service (by means of HTTP for HTML page retrieval services or SMTP / POP3 for electronic mail services), to control flow reservations (by means of RSVP) or to manage routing tables and routers (SNMP).

The WAN interconnections of local corporate networks, in which CTI ("Computer Telephony Integration") servers control the corporate PABX, represent another kind of full-fledged information networks. Incoming and outgoing calls can be processed, controlled, negotiated on a separate kernel network (TCP/IP), before the actual connection establishment.

Thus an important phenomenon is currently occuring : control-oriented or management-oriented information networks are emerging both in private and public networks, with unfortunately very few attempts to provide interworking between them.

## 2.3 Drivers for an interworking of the information networks

One possible driver for such an interworking between the various control-oriented and management-oriented information systems could be a regulatory act, requiring more openness at the control and management level (Kung, 1995), in the same vein of the one requiring the interconnection of the transport networks (i.e. access and transmission networks).

Another driver for such an interconnection is new service provisioning. Internetworking between customer premises equipements and public networks was the first step, interworking between the corresponding control and management systems is now the challenge to meet: it will enable new service offers that will benefit to all actors and will be more cost-effective.

For example, freephone services offered by public operators and corporate call center services do not currently interwork directly : if a client dials the freephone number of company C that has three call centers, the client call termination is not garanteed if the first proposed routing ends at a busy call center. As another example, Internet access services and intelligent call control services do not interwork neither : if a client is using a phone line to access the Web and a caller is trying to reach her, there is no means for the time being to notify the callee that she can suspend her PPP session for an incoming telephone call and no means to re-activate her PPP session after the call is terminated. One can easily find other services that would become possible if the control (or management) systems could interwork better, if they were 'seamless'.

## 3. REQUIREMENTS ON THESE SEAMLESS CONTROL AND MANAGEMENT SYSTEMS

Further more, if the advantages and drivers for interconnecting the control and management systems are taken in, the requirements upon these systems in order to garantee seamlessness and workability are straightly put up.

### 3.1 Requirement 1 : Identify the various information flows and their constraints

The semantics of the some control-oriented or management-oriented flows depends heavily upon the end-users, the telecommunications services, whereas for others it tends to become stable. For example, the information related to telephony call control is expected to keep on evolving in the near future, in order to integrate new service features like call presentation, incoming call screening, personal user mobility. On the other hand, bi-point or multi-point connection control information is likely to be stabilized.

Consequently, all information flows cannot (any more) be supported by a single application level protocol, let this application level protocol be broadband and specified for service integration (e.g. B-ISUP). This statement implies two requirements : i) the control-oriented and management-oriented information flows need to be finely identified and specified; ii) generic communication protocols such as remote procedure calls (DCE RPC, IN TCAP, OMG IIOP) should be used as a basis for supporting the various flows.

TINA-C worked out a control-oriented and management-oriented flow identification that is worth being illustrated here : a separation of concern has been proposed and specified between access control, service control, communication control, connection control, access management, service management, network resource management.

Access control includes user/terminal identification and authentification, access session management, customization of the service portfolio presentation, service directory, ... Service control corresponds to instantiating a specific service usage for the user (e.g. a conference call with maximum three parties, an information retrieval service which screens all java applets). Communication control corresponds to establishing 1-1, 1-n or m-n communications (binding objects in RM-ODP) between logical end-points, regardless of the actual physical end-point addresses and the transport network technology. Access management corresponds for example to managing one's profile, authentication data or access control policy, etc.
This work enables to better analyze the requirements and constraints upon each flow and to design the information systems accordingly.

## 3.2 Requirement 2 : Reuse control and management systems when possible

This requirement can be put in other words : the specification, design and development of a control and management system for each flow that a transport network needs to support is definitely not cost-efficient. Network designers should look for reuse, even partial. Of course, a system supporting for example connection control for an access network (e.g. DCS1800, DECT, GSM, RTC, FTTx) is so specific and tailor-made for a given technology that one cannot expect to reuse it for another access network[6]. By reuse here, it is meant the ability to use the services of a control or management system supporting a particular flow when designing the support system for another information flow; for example, a communication control system can be built upon another system supporting connection control.

To do so, all control and management protocols need to be specified according to the same model and language (e.g., the Interface Definition Language of OMG plus a formal language), in order for the designer to really compare the advantages and drawbacks of each and to choose one adequately.

[6]. Recent studies seem to prove that a single software system, well designed, could very well provide control (and management) to different kinds of transmission networks (RTC, SDH, ATM) (Nakamura, 1995)

One can understand that the exercise is far from being simple, after a glance at the candidate list : Q.931, Q.932 , Q.2931 or DSS2, GSM9.2, ISUP, ECMA QSIG, CMIP, SNMP, CMOP, DSM-CC, TCP/IP, INAP/TCAP, etc. This would nevertheless result in specifications like the following one :

```
interface SocketControl {

  void SocketRequest (
          in SHORT domain,
          in SHORT type,
          in SHORT protocol,
          out SHORT socket_id
  );
  void SocketConnection (
          in SHORT socket_id,
          in SOCK_ADR ptr_adr
          in SHORT adress_length,
  );
  };
```

## 3.3 Requirement 3: Provide better flexibility for the control and management service deployment

The basic software infrastructure of the control-oriented and management-oriented global system needs to be well balanced : an identical kernel of functionalities has to be present on each computing node, in order for the system engineer to deploy the control or management services conditionally to the quality of service he looks after, rather than to the basic processing functionalities requested by the services.

Currently, for example, signaling services are deployed according to a hierarchical algorithm : the signalling messages are processed first by local switches first, then by transit switches if it is a long-distance call, by a service control point if the service is 'intelligent', eventually by an international switch if it is an international call. This engineering architecture meets well the current signalling requirements and the E.164 numbering plan. On the opposite, communication control based on logical addresses (e.g., universal personal number) might require a different network engineering architecture, consisting in processing the address translation as soon as possible, for example in the local switches or in the service control points attached to them.

TINA-C proposes to base the processing environment of each information network nodes on the same core functionalities, encapsulated by a single API.

## 3.4 Requirement 4 : Provide more flexibility in the choice of the kernel transport network

The current kernel transport network deployment and the information network constraint diversity in terms of quality of service (jitter, bandwidth, delay) require to base the interconnection of all the information network computing nodes upon various kernel transport network technologies : quasi-associated signaling networks, IP networks, ATM VC/VPs, X.25 virtual circuits, etc.

The flexibility that will be looked for can be illustrated as follows : a freephone service mixed with a call center service. An incoming call for a corporate employee is currently routed by the public network to the corporate PABX, and processed in more and more cases by a CTI server. If the callee initially dials a corporate freephone number, the call can be processed by a service control point of the public network. This call is thus processed by two external servers, interconnected by two different kernel transport networks : SS7 and a line between the PABX and the CTI server. More flexibility could consist here in enabling direct and connection-less interworking, between the SCP and the CTI server.

## 3.5 Requirement 5 : Control and management independent of the platform providers

Since control and management services are mostly externalized from the transport network equipments, in order precisely to provide independence from the equipement technology, and to reduce the service life cycle, developing these now external services on monolithic and proprietary software platforms would be a really bad decision. The control and management services should rather be deployed and run on open distributed processing systems : OMG CORBA 2.0 request brokers and standard operating systems (X/Open, COSE, ...).

# 4. SOFTWARE ARCHITECTURES

The best way to satisfy the requirements given above is first to consider the control-oriented and management-oriented information networks like open distributed systems, second to specify the concepts, principles and rules - a software architecture - that these control and management systems should comply with.

A few software architectures exist now, like the Windows Object Service Architecture from Microsoft, The Intelligent Network Conceptual Model from ITU-T, The Computer Supported Telephony Application from ECMA, the DAVIC architecture, TINA from TINA-C (Dupuy, 1995), the Reference Model of Open Distributed Processing from ITU-T (Stéfani, 1995), the W3C architecture, the Java development kit, etc.

TINA seems to have a good ground : it is open to various technologies (IN, Java, DSM-CC, HTTP, SNMP, ORB, etc), it is non-prioprietary since jointly designed by a consortium, it is telecommunication-oriented. Nevertheless, it currently lacks greater publicity and support, in order to enlarge the user community to non public network actors (e.g., ECTF, ECMA). It also lacks large scale experimentation, as of the World Wide Web, in order to test its scalability and to measure its performance.

## 5. CONCLUSION

Control and management are adding value to the private or public telecommunicatons networks. They are currently evolving due to three major factors : the increase of the network technology diversity, the increase of processing capabilities at the public periphery, and reglementary acts. Quite surprinsingly, no attempt to interconnect the various - private and public - control and management systems has been made, excepted by military institutions and universities (Internet). A global, seamless control and management system, made of Internet, intelligent networks and computer telephony integration systems, should be targetted at, as it would really burst the service offers. TINA-C is on the way of specifying and standardizing the software architecture required for such a seamless control and management system. Nevertheless, more effort should be devoted to the task, in order to turn the vision now into reality.

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# 7 BIOGRAPHY

The author graduated from Ecole Polytechnique in 1988 and specialized in telecommunications at Telecom Paris in 1990. Joining CNET at Lannion in 1990, his first studies related to object-orientation and distributed systems applied to on-line services, e.g. Videotex. He worked for an internal CNET project on Intelligent Networks, before joining the TINA-C core team in 1993 for almost 2 years. Back in CNET Lannion since end 1994, he led a team in charge of experimenting TINA. Since January 1997, he is responsible for a R&D department on network software architecture and platforms.