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SDL Specification of Open Systems – Application in a Network for Personal Call*

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1. Introduction

One of the leading tendencies in the development of the telecommunication systems is the concept for open systems in the sense of OSI (Open Systems Interconnection) Reference Model recommended by ISO and CCITT (ITU-T) [1, 2].

According to OSI model each open system, an element of the network, is a hierarchical structure of subsystems (*N*-subsystems), *N*=1 upto 7, including one or more objects (*N*-Entity). The sets of subsystems of equal rank (*N*) form independent functional layers (*N*-layers): an application, a presentation, a session, a transport, a network, a data-link and a physical one. The functions executed at each layer (*N*-functions) are specified, as well as the services (*N*-Services, *N*-Facility), supplied for the upper *N*+1 layer. The interconnection of the systems in the network, regarded as logical connection (*N*-connection), is realized by the corresponding layer protocols (*N*-Protocols) and the real data exchange is done at a physical level.

The model is independent on the existing company standards of the different producers of devices and is appropriate for the modelling of a wide range of applied processes and protocols in OSI sense. In OSI-structured networks the including of a new network and of internetwork services and protocols does not require any alteration in the network architecture already built.

The description of the applied processes and the design of the protocols demand some formal tools, enabling the design, analysis, emulation and software realization of the system specifications. The Z.100 recommendations of CCITT [3] contain a principal possibility for the application of the Specification and Description Language (SDL) in the solution of similar problems. A specific characteristics of the language are the two forms of description: a textual one – SDL/PR (PR-Phrase Representation) and a graphical one – SDL/GR (GR-Graphics Representation) which have a common semantic model. This feature is a prerequisite for the building of software tools for the automatic design of information systems.

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In this connection the possibilities of SDL language have been investigated and analyzed by the comparison (semantic and syntactic) of the basic terms (objects) in OSI and SDL. The investigations and the results, represented in [4, 5] show that the recommendations [2] contain principles, which do not conform to the rules for SDL-circuits formation according to Z.100, and the compilation of SDL descriptions does not guarantee the discovery of errors in the specification. Besides this a number of basic OSI denotations such as layer, protocol linking, service and others, have no synonyms in SDL.

As a result of this analysis a modified formal tool, called SDL/OSI is recommended in [5], in which several differently named modifications of SDL-elements are defined and some specific restrictions and comments are suggested with the purpose to create new constructions, which have no equivalent in SDL.

The paper discusses the possibilities for specification of a type of interconnections in open systems (according to OSI) by means of SDL language and the offered SDL/OSI modification respectively. The study has been accomplished on a sample problem from a real telecommunication network.

2. Problem description and formulation

The system regarded is a telecommunication network for acquisition and transfer of data, that are a personal call of pager-users. The network structure is built on similar complexes M_i, i=1,...,3, each one of them including two types of computer devices (open systems): input computers (S_{ij}), j=1,...,8, connected through a commutator (CX) to a communication computer (R_i), further called a sending (S) and a receiving (R) system or side. The personal calls arrive through a telephone line and formatted they are input to S_{ij}, and afterwards are transferred to the corresponding R_i. The messages received are automatically recoded and transmitted through a M-15 Motorola type modulating device along the radiochannel of the corresponding pager-receiver (Fig. 1).

The purpose of the research are the interconnections in M_i among the sending S_{ij} and receiving R_i systems, the design of a model and the specification of the exchange in SDL/OSI terms under the following initial conditions. The data exchange is initialized by a sending system with the help of a request for connection. The receiving system sends an acknowledgement if resource possibilities are available, otherwise – a connection failure is reported. The session starts by a password and confirmation of the access. At each session one or more messages are sent and the result from the transmission of each message is separately acknowledged.

The communicating sides have equal rights in the initiative for a connection interrupt. The sending side – when the information is over, and the receiving – when the communication quality is deteriorated, when the given volume of received data is surpassed, when the system resources are decreased below a preset limit or if there is a connection fault. Timer mechanisms are foreseen at the two ends of the connection.

The physical exchange of the information is not discussed for the problem considered.

3. SDL model and specification of the interconnections (exchange)

The development of the model and the exchange specification are based on the following formulations, principles and assumptions:

3.1. A network structure and character of OSI interaction. – For convenience of the exposition, only one complex is discussed – M1 from the network. Besides this we assume that the sending system (S1) is one, i.e., j=1, connected through a commutator to the receiving system (R1). The simplification is admissible, since all M_i have similar structures, and the exchange between S_{ij} and R_i is built on one and the same protocol rules.

At this formulation each N-layer in OSI model of M1 includes two subsystems N-S1 and N-R1. The interconnections described in the problem refer to the establishment of the connection, the check and control of the "dialogue" at data exchange. These functions in OSI model are characteristic for the processes and protocols at the session layer (N=5).

3.2. SDL/OSI system model (modelling and specification). According to the Reference Model, the open systems interact at any N-layer with the help of N-connection, messages and signals and they exchange data through physical layer channels. The connections (logical links) and the channels are dynamic constructions, created, altered and removed during the process of network functioning. There is no equivalent construction in SDL, but in this case it can be regarded as interacting processes among objects of different systems. The following assumptions have been made in SDL/OSI notation: the connections are logical and physical channels, established at the processes level; the connections are established upward-down among the objects, i.e. among the subsystems of each of the interacting systems, as well as among the subsystems of one and the same rank (N), i.e. at (N)-layer, the N-functions of which correspond to the character of the interactions.

– The modelling of the system observes the top-down principle accepted in SDL language. The process starts with the representation of the system by abstract information objects (AIO), subjected to decomposition after that.

In the case being considered, AIO defined in SDL/OSI, are a system, a subsystem, a channel, a process and service. Each AIO can be represented by one decomposition SDL-diagram only, containing AIO and/or elementary information objects (EO). The last ones are not subjected to decomposition. According to SDL/OSI the elementary objects are input, start, state, task, decision, save, output, alternative, procedure and so on.

– The system model is the set (A), the elements of which (A_i), i=1, n are the SDL diagrams and the relations (R) among them, i.e.

$$A = \{A_1, A_2, \ldots, A_n, R\}.$$

On its turn SDL diagrams are also sets, the elements of which are AIO and EO, connected by relations.

In the graphical SDL/GR version each AIO and EO is denoted by a unique symbol.

The syntactic and semantic correctness of the SDL-diagrams designed is assured keeping the rules for admissible relations among the sets from AIO and AIO, EO.

3.3. SDL model and diagrams of the specification of the interconnections: Fig. 2 shows a Functional Diagram of a Block (FDB), where the interconnections between the sending 5 [S1] and receiving 5 [R1] subsystems are described by process P5 [S1] and P5 [R1]. The signals, which are an element of the protocol rules are represented in the specifications of the channels and the connections. The last ones are one-directional in SDL by default and are established during the data exchange between the session (N=5) and the presentation (N=6) layers (interface interactions) and among the sending and receiving subsystems in the session layer (protocol interactions). The signals semantics is as follows:

a) interface interactions

For the channel Ch 6S_1: L – a request to transfer a package from l (l=l–n) messages; Es – a request to interrupt the process P5 [S1}.

For the channel Ch 6S_2: Ok – a successful finish of the session: En – an acknowledgement to interrupt the process P5 [S1]; Psw – an acknowledgement for transmission right; U-l – a successfully transmitted message l; Eri – a corresponding signal for incorrect running of the session.

For the channel Ch 6R_1: Es – a request to interrupt the process P5 [R1];

For the channel Ch 6R_2: Ok – successful accomplishment of the session; En – an acknowledgement to interrupt P5 [R1]; Ko – sharing a resource, a result of a remote request for a session; Re – a confirmed right for transmitting access; U – a received message; Eri – a corresponding signal for incorrect run of the session.

b) protocol interactions

For the channel Ch 5_1: R – a request for a session from P5 [S1]; Ps – a password of the sending process; Di – successful interrupt of the session; Ms – a message for one pager-user.

For the channel Ch5_2: A – (ACK) – an acknowledgement for the connection establishment; N – (NAK) – a refusal for connection; Pid – confirming the validity of the password and the right to transmit; Un – an invalid password; Wr – an acknowledgment of message Ms; Nn – a refusal for message Ms due to an invalid user identifier; Bc – a refusal for Ms due to bad complecting of the CCF form; Bo – end of the session due to an overflow in the admissible number of incorrect messages C per one session; Ov – end of the session due to an overflow in the admissible number of messages N per one session.

Fig. 3 shows the Generalized Flow Diagrams of a Process (GFDP) of the processes P5[S1] and P5[R1], where the last ones are decomposed and described with the help of the elementary objects state. The two sets of states characterize the stages (phases) of the protocol dialogue designed, and the relations between them – the logical conditions for passing from one phase (stage) to another, namely:

– the couple of states REQUEST [send] and CONNECT [receive] are the initial states of P5 [S1] and P5[R1], when it is possible to initialize a session. The session is initialized after the receiving of L signal from P5[S1] and P5[S1] passes to state CONNECT [send].

– the couple of states CONNECT [send] and CONNECT [receive] corresponds to the "dialogue" stage for connection establishment;

– the couple of states PASSWORD [send] and PASSWORD [receive] corresponds to the established connection between P5[S1] and P5[R1] and a dialogue for receiving access to the messages;

– the couple of states MSG [send] and MSG [receive], where MSG is a cyclic state,

corresponds to acknowledged access and dialogue at normal data exchange;

– STOP is the final state, terminating the processes.

On GFDP diagrams the signals, leading to the passing from one state to another at normal session are represented by a "commentary record". The connections not named are processed during "failure" situations.

Fig. 4 (a,b) and Fig. 5 (a.,b) show the Full Flow Diagrams of a Process (FFDP) for the processes P5[S1] and P5[R1], in which the relations, represented in a generalized form of GFDP in Fig. 3, are represented in detail and explicitly described. The description is at elementary SDL-objects level in START, INPUT, SAVE, OUTPUT, TASK, DECISION cases. FFDP diagrams, which are the lowest abstract level in SDL/OSI model, complete the process of modelling and protocol formal description. It is possible to trace and analyze the characteristic features of the processes P5[S1] and P5[R1], occurring in the interconnection behaviour and in the processes behaviour:

a) interconnection behaviour:

– The processes are asymmetrical. The asymmetry, structurally reflected by the REQUEST state of P5[S1], is a consequence of the condition, that the session is initialized by the sending side only;

– At an arbitrary moment of the current session, each subsystem of an upper level (N=6) can require an interrupt (signal Es) of the corresponding process. The interrupt request is satisfied under certain conditions, that are different for the two processes.

The conditions in the sending side (S1) are the following: if the process is in a REQUEST or PASSWORD state, there is a reaction immediately after Es is received; if the process is in a CONNECT or MSG state – after passing to the next state.

The conditions for the receiving side (R1) are as follows: in case the process is in a CONNECT state – immediately after Es signal is received; if the process is in a PASSWORD or MSG state – after passing to a CONNECT state.

b) process behaviour

A protection is set at the two terminals of the connection for failure interrupt of the session, due to channel falling. The protection is realized by timer mechanisms, which are an inner function (event) of the processes. The timers count the time interval T_k, $T_k = k$ – a preset value for the receiving of the defined signal expected, denoted in the specification of the channels Ch 5_1 or Ch 5_2 (Fig. 2). An indication for channel falling are the signals (time-outs) t_k, generated by the respective timers.

In the case discussed the timers for the sending side are three, and for the receiving one – two. The conditions for the generation of the signals t_k are as follows:

– for the sending side P5[S1] (Fig. 4)

t_1: at time delay T_1 in the receiving of signals A or N, a reply of R; t_2: at time delay T_2 in the receiving of the signals Pid or Un, an acknowledgement of Ps; t_3: at time delay T_3 in the receiving of the signals Wr Nn Bc, Bo, Ov.

– for the receiving side P5[R1] (Fig. 5)

t_4: at time delay T_4 in the receiving of the signal Ps, an acknowledgement of A; t_5: at delay T_5 in the receiving of the next message Ms or the signal Di.

In case of a channel fault the timer mechanisms return both the processes to their initial states.

4. Conclusion

Despite of the partial character and specifics of the OSI interconnections being investigated, the following more general statements and conclusions can be made on the basis

of the SDL model received, that refer to the software interpretation and realization of SDL system specifications:

– The graphical SDL/GR notation uses the symbolism and constructions similar to the conventional block diagrams in applied programming;

– The specification with the help of flow diagrams reflects the logics of the communication processes at several abstract levels, which enables the apriori determination of the points for processes observation at simulation and setup of the software insurance;

– The graphical SDL model enables the selection of the places for software modules mounting, which accomplish the monitoring of the system for the purposes of diagnostics and registration of its state in selected operation moments.

– The object orientation of SDL constructions enables the explicit defining of the objects in the systems and facilitates the creation of their prototypes and the defining of the operations among them. This is useful in all the cases of software realization, since the object approach is applicable not only at operation with object-oriented programming languages.

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SDL-спесификация открытых систем – применение в сети персонального позыва

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(Резюме)

В работе исследуются возможности языка описания и спесификации SDL и графическую SDL нотацию для моделирования OSI прикладных процессов. Исследования базируются на основе модификации языка, названной SDL/OSI. Моделлированы тип взаимодействий, характерных для сессийного слоя реальной телекоммуникационной сети.

Описывается процесс проектирования SDL модели и дискутируются возможности программной реализации графических системных спесификаций.