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THE MODELLING OF IEEE 802.2 LLC TYPE 3 PROTOCOL WITH GENERALIZED NETS

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1. Introduction

With the increasing complexity of communication systems, it has become more and more difficult to construct models that are analytically tractable. Numerous researchers turned to simulation as the method to evaluate the performance of communication systems. Many tools are proposed for investigating the usage and performance analysis. Some of the tools have not formal definitions. Communication protocols are modeled with Petri Nets (PNs) in many cases. However, many kinds of PN are used according to the type of the protocol and the needed evaluation. Proposed are Elementary PNs, Place/ Transition PNs, Coloured PNs, Timed PNs, Stochastic PNs and other modifications. Different kinds of PNs require different program products for analysis. To overcome those problems, Generalized Nets (GNs) [2] are proposed as modelling tool. GN models are more powerful than PN models. GNs are universal tool and we can use specialized unique software. In this paper is described modelling of IEEE 802.2 LLC Type 3 Protocol with Generalized Nets.

2. IEEE 802.2 LLC Type 3 Protocol

The LLC Type 3 Protocol adopts the stop-and-wait scheme for the error control and the flow control as the alternating bit protocol [1]. The sender component waits for an acknowledgment after a single transmission. If either a negative acknowledgment arrives or the acknowledgment timer expires after the acknowledgment time value (T1), the frame is transmitted as long as the maximum number of transmissions (N4) is reached. For the transmission mechanism, the sender component has the retry count to keep the number of transmissions for a specific data send. The receive sequence state variable of the receiver component stores sequence number of the frame to be received and is used to detect duplicate frames. The receive sequence state variable is destroyed after expiration of the receive variable lifetime timer, associated with receive lifetime value (T2). The transmit sequence state variable of the sender component stores sequence number of the frame to be transmitted or the outstanding transmission. The transmit sequence state variable is used to relate a received acknowledgment with the outstanding transmission and allow the receiver to detect duplicate frames. The transmit sequence state variable is destroyed after expiration of the transmit variable lifetime timer, associated with transmit lifetime value (T3). The transmission delay is bounded by transmission delay value (Td). The values of those logical link parameters are determined on a system-by system basis. The proper operation of LLC Type 3 Protocol requires that the logical link parameters be set appropriately. Logical link parameters of a single link are T1, T2, T3, N4 and Td.

3. Timed Petri Nets Model of a Single Link

Timed Petri Nets for modelling of a single link has been considered by Moon, Moon and Kwon [3]. It consists sender, receiver and four transmission line components. The merged model consists of 25 places and 25 transitions. There are used retry count, conditional transitions and inhibitor arcs.

4. Generalized Net Model of a Single Link

Proposed GN model has a simpler graphical structure. It consists 3 transitions. There are used predicates to evaluate the performance. There are used tools specific for GNs: GN transitions and places, index matrices, characteristics of tokens, time components [2]. Figure 1 shows graphical structure of the model.

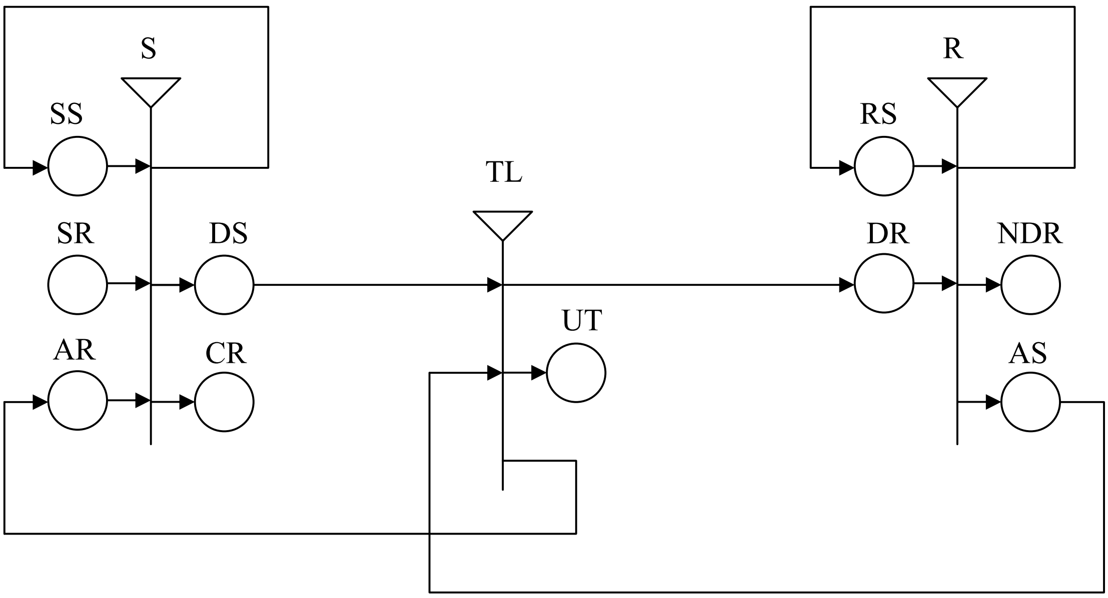

Fig. 1. Graphical structure of Generalized Net model of a single link.

A short explanation for places and tokens is proposed at first and the strict description of the GN model is offered after that.

The transition S describes the sender component. There is always one token in SS. This token defines the state of the sender component. This token has four characteristics. The first characteristic is the value of the transmit sequence state variable. The second characteristic is the number of transmissions after the last fixing of the transmit sequence state variable. The third characteristic is the moment of the last fixing of the transmit sequence state variable. The fourth characteristic is the moment of the last transmission. However, the fourth characteristic is the same as the third if the value of the second characteristic is zero. A token in SR denotes that a data send request from a user has arrived. A token in AR with first characteristic 0 or 1 denotes that the acknowledgement with the sequence number 0 or 1 respectively has been received. A token in DS signifies that a data frame is sent. The tokens in DS have two characteristics: the sequence number of the data frame and the moment of the transmission. Tokens in CR show successful or unsuccessful completion of a data send.

The transition R describes the receiver component. There is always one token in RS. This token defines state of the receiver component. This token may obtain as a first characteristic NO, 0 or 1.The first case displays that the receive sequence state variable does not exist. Otherwise, its value is 0 or 1 respectively. The second characteristic of the token in RS is the moment of the last fixing of the receive sequence state variable. The arriving of a token in DR signify that a data frame has been received. Token in AR with characteristic 0 or 1 denote that the acknowledgement with the sequence number 0 or 1 respectively is sent. A token in NDR denotes a new data frame has been reported to the user. The token in AS signify that an acknowledgement is sent.

The transition TL describes the transmission line component. Tokens in UT indicate unsuccessful transmissions of data frames or acknowledgements.

The strict description of the GN model is as follows.

Let logical link parameters for a single link are T1, T2, T3, N4 and Td.

Let the initial moment of functioning of the LLC Type 3 Protocol for a single link is t0. There is token in SS with characteristics (0,0,t0,t0) at moment t0. There is token in RS with characteristics (NO,t0) at moment t0.

Current time is t.

Let (+) denote the sum mod 2.

The index matrix of predicates for transition S is:

	SS	DS	CR
SS	R(SS,SS)	R(SS,DS)	R(SS,CR)
SR	FALSE	R(SR,DS)	FALSE
AR	FALSE	FALSE	TRUE

Let the token in SS has characteristics (TSSV, K, tfirst, tlast) at moment t.

R(SS,SS) = C1 OR C2 OR C3 OR C4 OR C5
R(SS,DS) = C2
R(SS,CR) = C3
R(SR,DS) = “K=0”,

where
C1 = “K>0” & “There is token in AR with characteristic TSSV(+)1.”
C2 = “1≤K<N4” & “t≥tlast+T1” & “There is not token in AR with characteristic TSSV(+)1.”
C3 = “K=N4” & “t≥tlast+T1” & “There is not token in AR with characteristic TSSV(+)1.”
C4 = “K=0” & “There is token in SR.”
C5 = “TSSV=1” & “K=0” & “t≥tfirstst+T3”.

After the checking of these predicates tokens are transferred simultaneously. If any token may go to more then one place, this token split up into some tokens according to the algorithms for GN-functioning (see [2]). The token transfer in the whole GN model is the same.

A token in SS obtains the characteristics as follows: (TSSV(+)1, 0, t, t) if C1 holds; (TSSV, 1, tfirst, t) if C4 holds; (TSSV, K+1, tfirst, t) if C2 holds; (TSSV, 0, t, t) if C3 holds and (0, 0, t, t) if C5 holds. A token in DS obtains the characteristics (TSSV, t). A token in CR obtains the characteristic “successful completion of a send” if arrives from AR and the characteristic “unsuccessful completion of a send” otherwise.

The index matrix of predicates for transition R is:

	RS	AS	NDR
RS	R(RS,RS)	FALSE	FALSE
DR	FALSE	TRUE	R(DR,NDR)

Let the characteristics of the token in RS are (RSSV, tr) at moment t. Let the characteristic of the token in DR is SV at this moment if there is a token in DR.
R(RS,RS) = C6 OR C7
R(DR,NDR) = C6,
where
C6 = “There is a token in DR.” & “NOT (RSSV(+)SV=1)”
C7 = “RSSV≠NON” & “t>tr+T2”.

A token in RS obtains the characteristics (RSSV(+)1, t) if C6 holds and the characteristics and the characteristics (NON, t) if C7 holds. A token in AS obtains the characteristics (SV(+)1, t). A token in NDR obtains the characteristic “the arrival of a new data”.

The index matrix of predicates for transition TL is:

	DR	AR	UT
DS	R(DS,DR)	FALSE	R(DS,UT)
AS	FALSE	R(AS,AR)	R(AS,UT)

Let the first characteristic of the token in DS is DSV and the second its characteristic is tds at moment t. Let the first characteristic of the token in AS is ASV and the second its characteristic is tas at moment t.

R(AS,AR) can obtain value 0 or 1 if “tas<t≤tas+Td” and 0 if “t>tas+Td”. R(DS,DR) can obtain value 0 or 1 if “tds<t≤tds+Td” and 0 if “t>tds+Td”. The values of these two predicates define the certainty of the transmission line.
R(DS,UT) = “t>tds+Td”
R(AS,UT) = “t>tas+Td”

A token in DR obtains the characteristic DSV. A token in AR obtains the characteristic ASV.

5. Generalized Net Modelling of IEEE 802.2 LLC Type 3 Protocol.

Till now, only a single link has been considered. Since all the links established in a station are affected by a single parameter set of the LLC Type 3 Protocol, the parameters in a station should be set with consideration for the parameters of the other stations that may establish links with it. Let $Sn=\{i \quad 1\leq i\leq n\}$ denote the set of stations in a network and $L=\{(j,k) \quad (j,k) \in Sn\times Sn \ \& \ j\neq k\}$ denote the set of ordered pairs of stations that may establish links. (j,k) denotes that a station j may establish links with a station k to send data to it. T1(i), T2(i), T3(i) and N4(i) denote parameters of the LLC Type 3 Protocol at a station $i\in Sn$. Td(j,k) denote the transmission delay between stations i and j ($i,j \in Sn$, $i\neq j$). Td(i,j)=Td(j,i) for any $i,j \in Sn$.

The GN model of the LLC Type 3 Protocol can be obtained if two places are added to the GN model of a single link. The first place defines the stations that send and receive data frames respectively in every moment. The second new place defines the set of parameters. Instead the single parameters in above-mentioned model in new model will be used parameters of the established links. It is impossible to do this with the Petri nets, proposed in [3]. The proper operation of LLC Type 3 Protocol requires that the logical link parameters be set appropriately.

References

[1] ISO / IEC 8802-2: Logical Link Control, IEEE, Inc., 1994.
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[3] Moon, H. , Moon, S. , Kwon, W. Parameter Region for the Proper Operation of the IEEE 802.2 LLC Type 3 Protocol: A Petri Net Approach. Lecture Notes in Computer Science, vol.1605, p.131-149. Springer Verlag, 1999.