A Telephone Network System

Modified from "The SPIN Model Checker (Gerard J. Holzmann)" Book

Singapore University of Technology and Design (SUTD), Singapore

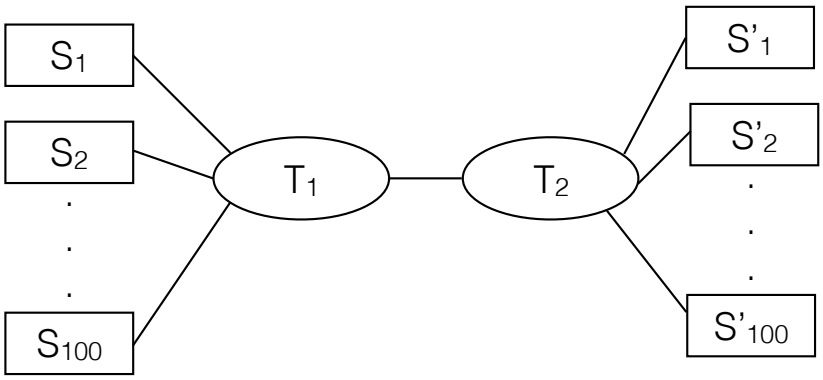

Fig. 1. A telephone network system

A telephone system consists of several switches and subscribers. A subscriber can make a call by lifting her telephone receiver and dialling a phone number. Successful completion of a telephone call results in a ringtone at the receiver's end (corresponding to the dialled number). An incoming telephone call is answered by a subscriber when she hears a ringtone and lifts the telephone receiver. Each subscriber in the telephone network has a local switch. For each telephone call, the caller first contacts its own local switch, which in turn contacts the local switch of the callee (defined as remote switch with respect to the caller). The remote switch (with respect to the caller) finally contacts the callee. The process is more clearly explained with an example in Figure 1. In Figure 1, S1 and S2 have local switch T1. On the other hand, S1' and S2' have local switch T2. Following message exchanges happen when S1 calls S1': 1) S1 sends message to T1, 2) T1 sends message to T2 (for this call, T2 is the remote switch with respect to S1) and 3) T2 sends message to S1'. However, S1 may call S2 and in such cases, local and remote switch are the same (T1 in this case). For the sake of simplicity in this assignment, we shall assume that there are no intermediary switches required between the local and remote switch. Therefore, any telephone call may traverse at most two telephone switches.

Subscriber

1. Subscribers can make outgoing calls or receive incoming calls. To make an outgoing call, the subscriber first lifts the telephone receiver and dials a telephone number. To answer an incoming call, the subscriber lifts the telephone receiver after hearing a ringtone. A subscriber may always choose not to answer an incoming call.

2. A subscriber cannot receive multiple incoming calls and also cannot make multiple outgoing calls at the same time. Moreover, a subscriber cannot make an outgoing call and receive an incoming call at the same time.

Telephone Switch

1. The task of a telephone switch is to route different telephone calls. A telephone switch can either act as a local switch or a remote switch. When a subscriber lifts the telephone receiver, the local switch corresponding to the subscriber sends a `DialTone` message to the subscriber.
2. A subscriber may dial an invalid number (a phone number for which no remote switch can be found). In this case, the local switch of the subscriber sends an appropriate error message to the caller.
3. A local telephone switch can determine the remote switch for a particular outgoing call. After receiving the dialled number from the subscriber, the local telephone switch sends a message `Req` to the corresponding remote switch. When the remote switch receives the `Req` message, it does the following:
   (a) it first acknowledges receiving `Req` by sending a reply back to the local switch, and,
   (b) it sends a `RingTone` message to the callee to answer the call.
   Upon receiving the reply from the remote switch, the local switch then sends a `WaitTone` message to the caller. If the callee answers the call, the remote switch sends another message `ConnectSuccess` to the local switch. The local switch then turns the `WaitTone` off and establishes the connection between the caller and the callee. The callee, however, may not receive the call or may be busy answering a different telephone call. In both the cases, therefore, the remote switch returns a `ConnectFailure` message to the local switch. The local switch then sends a `BusyTone` message to the caller.
4. If a telephone call is terminated by the caller (*i.e.* the caller places the receiver first), a `Release` message is first sent to the remote switch by the local switch. The remote switch generates a `BusyTone` to the callee and acknowledges the `Release` message by a reply message `ReleaseConnection`. On the other hand, if the telephone call is terminated by the callee, the remote switch sends a `ReleaseConnection` message to the local switch to state that the call has been terminated. The local switch in turn sends a `NoTone` message to the caller.

Telephone Call

1. A telephone call consists of a caller and a callee. Both the caller and the callee must be subscribed to the telephone system for a valid telephone call.
2. There could be multiple established telephone calls in the telephone system. However, no two telephone calls share a caller or a callee.

More details

1. For simplicity, you can assume a fixed number of switches and a fixed number of subscribers in your modeling. However, both the number of subscribers and the number of switches must be more than three. Moreover, more than one subscriber may have the same local switch.

2. It is possible that both the caller and the callee have the same local switch. Therefore, the local switch and the remote switch might be same for a particular call. In that case, the message exchanges between the local and the remote switch are unnecessary.
3. Initially there are no active telephone calls and all subscribers are idle.
4. Caller and Callee are just defined for a particular telephone call. Note that both the caller and the callee for any telephone call are subscribers.