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A Generalized Model for Link Layer Triggers

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Abstract

This document presents a generalized model for supporting L2 triggers in 802 networks. Key L2 triggers that can be used in the handoff process are also identified. Examples of the use of these triggers are given.

These proposed triggers and the proposed trigger may form the basis for a generalized trigger service to be defined in 802.21. Feeback from developers of the layer 3 protocols that may use triggers is requested

Generalized Model for Link layer Triggers

Introduction

Mobile devices are beginning to have multiple wireless interfaces. There is a need for these devices to move freely across different networks and achieve seamless handoff across heterogeneous wireless networks. Several L3 protocols and other applications seek to reduce L3 handoff latency in this process. Layer 2 triggers can provide information about events which can help layer 3 and above entities better streamline their handoff related activities. A generalized trigger model can provide abstraction for these layer 2 triggers across heterogeneous wireless interfaces.

General Trigger Model

In general, handoffs can be initiated either by the mobile node or by the remote network node. Different 802 network types follow different rules as to which end makes handover decisions. E.G. in 802.16 it is the base station (BS), in 802.11 it is the STA.

Triggers for these handoffs may originate from MAC, PHY or from above through the MAC SAP either at the Mobile node or at the base station. The source for these triggers can be either within the local stack or from the remote stack.

This suggests that triggers need to carry some identification of the source from where they came. This source identifier needs to include what layer in the stack is came from and whether it is from the local or remote stack. In shared media, peer to peer networks, such as 802.3, a MAC address would be required to distinguish between the possible end points.

If layer 2 triggers can be remote, within the bounds of an 802 connection or link, then that link must provide a layer 2 transport for the triggers. One such UDP based client server protocol is discussed in [1].

The 802 model provides for protocol multiplexing via ethertypes and the 802.2 LLC, enabling multiple layer 3 protocols to coexist over a link. Thus multiple layer 3 protocols may be interested in these triggers at the same time. So layer 2 triggers may have multiple layer 3 destinations. However it would be a mistake to push all triggers to all recipients. Certain layer 3 protocols may not need certain triggers or they may not comprehend them. We can expect a layer 3 protocol to understand what triggers it does comprehend.

This suggests that a means for a layer 3 entity to register its interest in the triggers it comprehends is required. Triggers passing up to layer 3 must be duplicated in the destination 802 stack and passed on to each of the interested layer 3 parties.

In examining the properties of triggers, it is clear that there are security considerations to be considered.

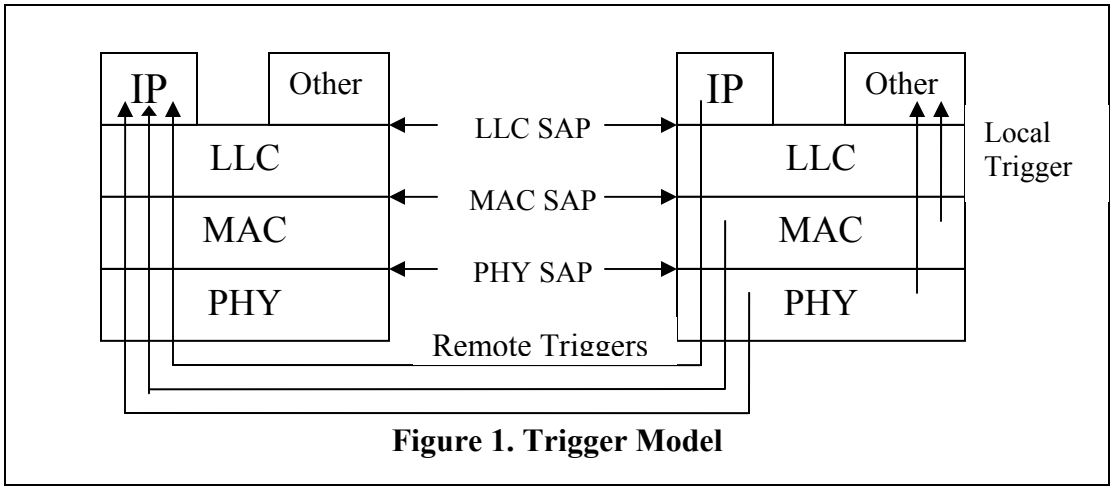

Figure 1. Trigger Model

These triggers are treated as discrete events. As such there is no general trigger state machine. However in certain cases a particular trigger may have time bounded state information associated with it, such as the Link_Going_Down trigger discussed below. In such cases the trigger may be assigned an *identifier* and other related events may be associated with the corresponding trigger using this identifier. However there does not seem to be a need to have an elaborate trigger state machine.

From a layer 3 perspective these triggers are mostly "advisory" in nature and not "mandatory". Layer 3 and above entities may also need to deal with reliability and robustness issues associated with these triggers. Higher layer protocols and applications may prefer to take a more "defensive" approach when triggers originate remotely as opposed to when they originate locally. Similarly, the appropriate response to a remote trigger may vary based on whether the transported trigger is known to be authentic.

Trigger Semantics

To be both general and useable by layer 3 protocols, the semantics of layer 2 triggers must be in terms relevant to layer 3. A common example of layer 2 information that compares very poorly between different link types is that of signal quality metrics. Whereas the availability of transport of class 1 frames is information directly useful to layer 3 that has similar meaning across media types.

Layer 2 triggers are classified into two types, *predictive* and *event* triggers. Predictive triggers express a likelihood of a change in system properties in the future. Since they attempt to predict the future, they may be incorrect and there is a benefit in being able to retract a predictive trigger. Event triggers describe a definite event that has occurred. Link_Up is an example of an event trigger. Link_Going_Down is an example of a predictive trigger.

Triggers carry certain fixed data with them. This includes the trigger type and the source. Predictive triggers carry predictive information, including an expected *time bound* for the occurrence of the event and a level of *confidence* that the event will take place.

The mapping of these triggers to specific layer 2 characteristics is technology and in some cases implementation specific.

The anticipated model for communicating layer 2 triggers to higher layers is through MAC SAP (or LSAP) trigger primitives. This is based on the observation that triggers behave in a similar way to data. They are asynchronous, independent units of data with defined semantics. So the MAC SAP that in 802 is design to carry data also provides a suitable interface for triggers. The method of communicating these triggers to higher layers is also implementation specific.

The 802 management model provides a less good match for triggers. MIBs are primarily an accessible storage for system state and this is an unnecessary capability for triggers that are either instantaneous or very strictly bounded in time.

The following L2 triggers are identified to aid in the handoff process.
1) Link_Up
2) Link_Down
3) Link_Quality_Crosses_Threshold
4) Link_Going_Down
5) Link_Going_Up
6) Trigger_Rollback
7) Better_Signal_Quality_AP_Available

Below is a brief description of each of these triggers.

Link_Up

The Link_Up trigger is an indication that Layer 3 can now send packets over the link. All Layer 2 activities in configuring the link etc. are expected to be complete at this point. Thus in case of 802.11 networks with 802.11i security, Link_Up would mean that a station not only has been Associated with an AP, but the 4-way handshake has been completed.

Trigger Type
event
Source
{local | remote | source MAC address}

Parameters:
Type of link
MAC Address of Mobile Node
MAC Address of old Access Router (if any)
MAC Address of new Access Router
Network Identifier for detecting possible change in subnet
(SSID+BSSID acts as a unique identifier in case of 802.11 networks)

Link_Down

The Link_Down trigger is an indication that Layer 3 cannot send any more packets over the link.

Trigger Type
event
Source
{local | remote | source MAC address}
Parameters:
Type of link
MAC Address of Mobile Node
MAC Address of old Access Router (if any)
Reason for why the link is down

Link_Quality_Crosses_Threshold

Link quality has crossed a certain threshold and has remained above or below that threshold for a certain period of time. Layer 3 and above may want to prepare for Handoff in such cases. There is no need to initiate handoff at this time. New Network Selection may be a step at this stage. Layer 3 entities can specify several triggers corresponding to multiple threshold levels to better streamline their activities with the handoff process. A judicious use of these threshold crossing triggers can provide increased reliability and consistency in communicating the link layer events to layer 3 and above.

Trigger Type
event
Source
{local | remote | source MAC address}

Destination

Parameters:
Type of link
MAC Address of Mobile Node
MAC Address of old Access Router (if any)
MAC Address of new Access Router
Network Identifier for detecting possible change in subnet

Link_Going_Down

A Link_Going_Down trigger implies that a Link_Down is imminent within a certain time interval. If Link_Down is NOT received within specified time interval then actions due to previous Link_Going_Down may be discarded. Another Link_Going_Down trigger can be received only after specified time interval has elapsed. Link_Going_Down trigger may be used as a signal to initiate handoff procedures.
A Trigger_Abort trigger, carrying the same identifier will indicate a withdrawl of the prediction made in the original Link_Going_Down trigger.

A 100% confidence would indicate certainty of the link going down within the time bound specified. For examples, a BS that has chosen to disable a connection for administrative reasons may send a 100% confidence in the link going away. Predictions made based on signal quality would typically have a lower confidence level.

Trigger Type
predictive
Source
{local | remote | source MAC address}

Parameters:
Type of link
MAC Address of Mobile Node
MAC Address of old Access Router
MAC Address of new Access Router (if any)
Time bound within which link may going down
Confidence level (%) of the link actually going down within specified time interval
A unique trigger identifier

Link_Going_Up

Link_Going_Up is used in cases wherein the wireless network takes a long time to initialize. In such cases the pending availability of a particular type of network may influence decisions related to Network Detection and Selection at Layer 3 and to initiating handover procedures from an existing connection.

Source
{local | remote | source MAC address}

Parameters:
Type of link
MAC Address of Mobile Node
MAC Address of new Access Router
Time bound within which link is going to be available
Confidence level (%) of the link actually going up within specified time interval
A unique trigger identifier

Trigger_Rollback

Trigger_Rollback is used in conjunction with Link_Going_Up and Link_Going_Down. In case of Link_Going_Down in the time interval that the link is expected to go down, if things start going otherwise and if the link actually starts going up, then a Trigger_Rollback message is sent to the Trigger Destination. Similarly in case of Link_Going_Up in the time interval that the link is expected to go up, if things start going otherwise and if the link actually starts going down, then a Trigger_Rollback message is sent to the Trigger Destination. The Destination should disregard or rollback the changes associated with the trigger ID in such cases.

Source
{local | remote | source MAC address}

Parameters:

Type of link
MAC Address of Mobile Node
MAC Address of new Access Router
A trigger identifier previously used in call to Link_Going_Up or Link_Going_Down

Better_Signal_Quality_AP_Available

Better_Signal_Quality_AP_Available specifies that the Mobile Node may have the possibility of attaching to another AP or Base Station which may have better link quality than the AP or Base Station to which the Mobile Node is currently attached.

Source

{local | remote | source MAC address}

Parameters:

Type of link
MAC Address of Mobile Node
MAC Address of new Access Router

In some cases the mobile device may actively procure “Scan list” or “Neighborhood list” to figure out the list of neighbor APs or base stations. However the Better_Signal_Quality_Available trigger helps in notifying the higher layers the event when a specific AP or base station offers significantly better link quality connection than the current one used by the mobile device. There may be situations wherein layer 3 and above may need to make AP or base station selection for handoff on other factors, such as cost , availability of a particular service, etc. as well.
Mapping of these triggers to different wireless protocols is technology and implementation specific. Further the various thresholds and other limits used in above functions for generating L2 triggers are platform and implementation specific.
Mobile devices may go through other power management states such as “sleep”, “suspend” and “resume”. Typically in these states the radio device is either off, inactive or unavailable. When the device emerges from these states, the state of L2 is restored to what it was when the device entered thee states. As such these states should not result in any additional link layer triggers.

Examples

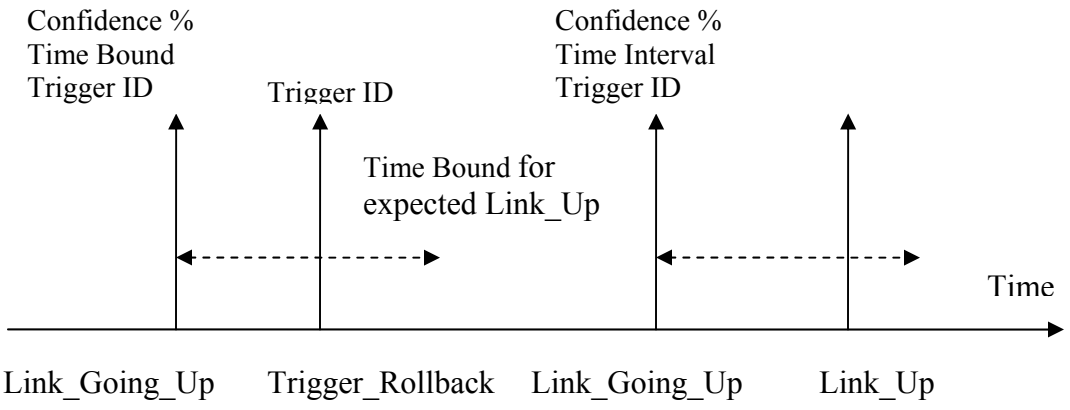

Figure 2. Link Going Up with Rollback

Figure 2 above shows a case where a Link_Going_Up trigger is followed by Trigger_Rollback trigger. In this case it was determined that the link will be unable to come up within the Time Interval parameter specified with Link_Going_Up trigger. As such the Trigger_Rollback trigger was sent with same Trigger ID as used in Link_Going_Up to clear the corresponding previous trigger instance. Subsequently another Link_Going_Up trigger is received and this time the link does come up within the specified time interval and a Link_Up trigger is received.

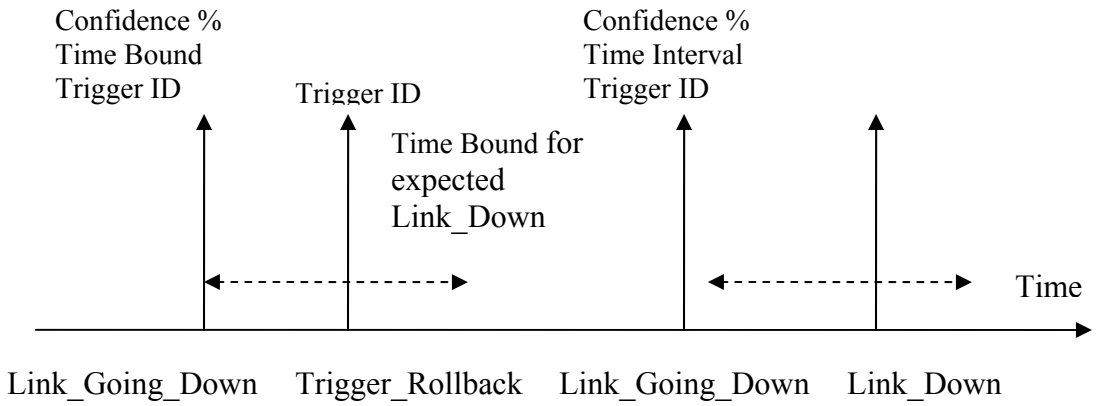

Figure 3. Link Going Down with Rollback

Figure 3 above shows a case where a Link_Going_Down trigger is followed by Trigger_Rollback trigger. In this case it was determined that the link will not fail within the Time Interval parameter specified with Link_Going_Down trigger. As such the Trigger_Rollback trigger was sent with same Trigger ID as used in Link_Going_Down to clear the corresponding previous trigger instance. Subsequently another Link_Going_Down trigger is received and this time the link does go down within the specified time interval and a Link_Down trigger is received.

The period in which a Link_Down is predicted by a Link_Going_Down provides time for a L3 Mobility protocol to prepare in advance for handover to another media or interface.

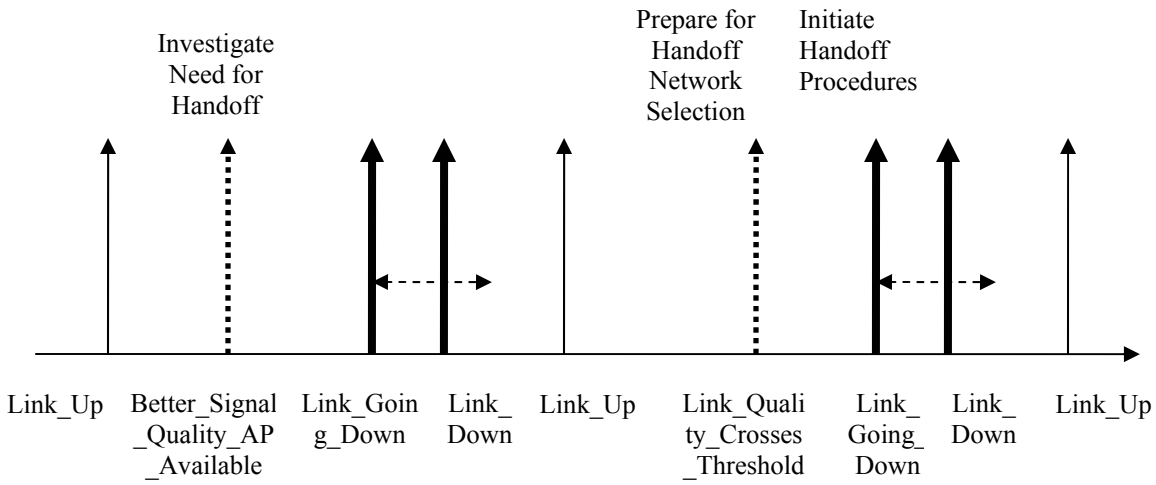

Figure 4. L3 Handover with L2 hints

Figure 4 above shows a case wherein the link is initially up. L3 through a trigger registration mechanism has solicited L2 link hits in the form of the Better_Signal_Quality_AP_Available trigger and the Link_Quality_Crosses_Threshold trigger. An AP with better link quality signal is detected. This calls for L3 examination of AP properties. This could involve a subnet change or an Administrative domain change and L3 needs to make an appropriate decision. Based on that L3 may decide to handoff to new AP in which case there would be Link_Going_Down, Link_Down and finally Link_Up triggers. If the new AP is within the same subnet as previous AP, then L3 may not need to reconfigure any IP routing and can possibly ignore these triggers. The triggers are just for "advisory" purpose only and it is up to L3 to take appropriate action.

Subsequently the signal quality starts degrading and L3 can start preparing for handoff when signal quality crosses a threshold. This could entail looking into Network Selection and Detection type of activities. And once it is imperative that the current link is going to go down, L3 can initiate handoff procedures.

This case must be distinguished from a L2 handover or 'micromobility' case, where L3 is not necessarily aware of the handover. Such an example would be an intra-ESS handover in 802.11. However the example shown might apply to a L3 handover between 802.11 APs that exist in different administrative domains or different subnets.

References

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