###  **IEEE P802.11Wireless LANs**

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| Max Channel Switch Time Harmonization |
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**Abstract**

**Revisions:**

* Rev 0: Initial version of the document.
* Rev 1: Changes after discussion at 11mf and offline
* Rev 2: Refinements after further offline discussion
* Rev 3: Changes after discussion at 11mf and offline
* Rev 4: Minor editorial
* Rev 5: Rebased to 11mfD1.0, additional fine-tuning, and now with a CID (CID 24)

***TGmf editor: Please note Baseline is 11mf D1.0. Edits are expressed via Word track changes:***

***Comment:***

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| 1047.33 | 9.4.2.17 | Brian Hart | There is some confusion in the industry about until when APs and clients can communicate before a channel switch, especially given the switch is not an instantaneous event and might even span multiple TBTTs. Text was written when switch times of ~10 msec were typical and the new beacon would appear at 10-20 msec on the new channel after the TBTT, but the language hasn't kept up: "For nonmesh STAs, the Channel Switch Count field is set to the number of TBTTs until the STA sending the Channel Switch Announcement element switches to the new channel. The value 1 indicates that the switch occurs at the next TBTT (the ensuing Beacon frame is created assuming the new channel)" | See direction/clarification in 25/269: i.e., AP's unavailability due to channel switching starts at TBTT when CSC would have equalled 0 and continues until done, which might be a fraction of a BI (and so the Beacon is transmitted) or potentially many BIs later. Then the "ensuing Beacon frame" is not directly linked to the next TBTT. Bottom line: clarification of switch start time and "ensuing". (While continuing to need to treat CSC=0 differently) | Revised – see changes in 25/269<motionedRev> that address the comment in a manner substantially aligned with the commenter’s proposed resolution.  |

***Discussion***

The definition of Max Channel Switch Time (“MCST element”; which*, for avoidance of doubt,* does not signify multicast) is inconsistent in many ways. It is the time between a start event and an end event, but how are each defined (and are they the most useful definitions?):

* Is the start time
	+ a) the TBTT of the last beacon frame or
	+ b) the actual transmit time of the last beacon?
* Is the end time
	+ 1) when the AP is first ready to communicate on the new channel,
	+ 2) the TBTT of the first beacon on the new channel or
	+ 3) the actual time of the first beacon transmitted on the new channel (which may be later than TBTT due to channel access delays)?
	+ 4) an upper bound on the actual time of the first beacon transmitted on the new channel (which may be later due to channel access delays)?

From below (using 11me un-re-based text), we see a mix of “a” and “b” and a mix of “2” and “4”.

Meanwhile, if the AP is ready to transmit on the new channel but (say) half a Beacon Interval before the next TBTT, the general intent of the protocol seems suboptimal:

* Communication has to wait until for that half a BI the next TBTT (which is bad for QoS traffic), and/or
* The AP should send an extra beacon at half a BI before its normal beacon, with undefined expectations in terms of countdown timers (e.g., for Quiet element), and/or
* The AP should disrupt its TSF: it should advance the TSF by half a BI so that the TBTT is aligned with the AP’s readiness to transmit on the new channel. However, dozing STAs might take an extended time to detect these time-translated beacons.

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| 9.4.2.216 Max Channel Switch Time elementThe Max Channel Switch Time element indicates the time delta between the **time** **the last beacon is transmitted by the AP in the current channel** and the **expected time of the first beacon** transmitted by the AP in the new channel. The format of the element is defined in Figure 9-835 (Max Channel Switch Time element format).…The Switch Time field indicates(#2047) the maximum time delta between the **TBTT of** **the last Beacon frame transmitted by the AP** in the current channel and **the TBTT of the first Beacon frame** in the new channel, expressed in TUs.(#3420) |
| 11.8.8.2 Selecting and advertising a new channel in a non-DMG infrastructure BSS… When the AP includes the Max Channel Switch Time element(#6), the AP shall **transmit the first Beacon frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element** after the **last Beacon frame transmitted in the current channel**, unless the AP determines that it is unable to operate on the new channel.(#1812)… A STA that receives a Max Channel Switch Time element from its associated AP should not transmit a frame to the AP on the new channel until it receives a frame on the new channel from the AP. |
| 11.9.3.2 Selecting and advertising a new channel in an infrastructure BSS… When the AP includes the Max Channel Switch Time element(#6), the AP shall transmit the first Beacon frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element after the last Beacon frame transmitted in the current channel, unless the AP determines that it is unable to operate on the new channel(#7160).… (#6)A STA that receives a Max Channel Switch Time element from its associated AP should not transmit a frame to the AP on the new channel until it receives a frame on the new channel from the AP. |

What seems to make better sense is:

* Start time for Switch Time should be a stable, well-defined time – i.e., TBTT of last beacon on the old channel aka “a”
* End time for Switch Time should a) be stable and well-defined (i.e., when frames are scheduled for transmission, not when actually transmitted) and b) be as early as possible, which might be between TBTTs. If the end time is between TBTTs, the AP should just schedule for transmission a broadcast unsolicited Probe Response (UPR). Alternatively, the end time can be an upper bound, if coupled with expected client behaviors that provide for earlier operation if possible.

In terms of conformance and interop:

* The spec has internally inconsistent requirements, so conformance is not possible by definition
* Industry testing of the MCST element suggests that preserving the notion of an “upper bound” is advised
* The author is aware of an implementation that doesn’t follow 2) or 3) and can indicate much later than 1) (and so the question of whether the AP follows a) or b) is moot). Non-AP STAs waking up at TBTT + MCST will find that the AP is (already) available but might not receive a beacon (or UPR), so might need to wait for up to a BI to get a beacon (or might actively scan the AP, leading to an unfortunate synchronized burst of probe requests)

In general we see opportunities for improvement:

* Remove inconsistencies
* Align with some industry expectations on APs
* Be more explicit about optimal client behavior (but without making legacy non-compliant):

***Accordingly, REVmf editor, please make the following changes under CID 24 indicated via Word track changes:***

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| 9.4.2.17 Channel Switch Announcement elementFor a channel switch, a STA transmitting the Channel Switch Announcement element first becomes unavailable for communications on the current channel and later becomes available for communications on the new channel. The time at which the STA becomes unavailable for communications on the current channel is referred to as the start of the switch.For nonmesh STAs, the Channel Switch Count field, if non-zero, indicates the number of TBTTs until the STA sending the Channel Switch Announcement element starts a switch to the new channel. The value 1 indicates that the start of the switch occurs immediately after the next TBTT (and the next Beacon frame is created assuming the new channel). The value 0 indicates that the start of the switch occurs at any time after the frame containing the element is transmitted.For mesh STAs, the Channel Switch Count field is encoded as an octet with bits 6 to 0 set to the time, in units of 2 TU when the MSB (bit 7) is 0, or in units of 100 TU when the MSB (bit 7) is 1, until the mesh STA sending the Channel Switch Announcement element starts a switch to the new channel. An octet with bits 6 to 0 indicates that the start of the switch occurs at any time after the frame containing the element is transmitted. For example, a duration of 200 TU until the start of the switch is encoded as X'82' and a duration of 10 TU until the start of the switch is encoded as X'05'. |
| 9.4.2.51 Extended Channel Switch Announcement elementFor a channel switch, a STA transmitting the Channel Switch Announcement element first becomes unavailable for communications on the current channel and later becomes available for communications on the new channel. The time at which the STA becomes unavailable for communications on the current channel is referred to as the start of the switch.For nonmesh STAs, the Channel Switch Count field, if non-zero, indicates the number of target beacon transmission times (TBTTs) until the STA sending the Channel Switch Count field starts a switch to the new channel. A Channel Switch Count field set to 1 indicates that the start of the switch occurs immediately after the next TBTT (and the next Beacon frame is created assuming the new channel). A Channel Switch Count field set to 0 indicates that the start of the switch occurs any time after the frame containing the Channel Switch Count field is transmitted.For mesh STAs, the Channel Switch Count field is encoded as an octet with bits 6 to 0 set to the time, in units of 2 TU when the MSB (bit 7) is 0, or in units of 100 TU when the MSB (bit 7) is 1, until the mesh STA sending the Channel Switch Count field starts a switch to the new channel. Bits 6 to 0 set to 0 indicates that the start of the switch occurs at any time after the frame containing the Channel Switch Count field is transmitted. For example, a duration of 200 TU until the start of the switch is encoded as X'82' and a duration of 10 TU until the start of the switch is encoded as X'05'. |
| 9.4.2.216 Max Channel Switch Time elementThe Max Channel Switch Time element indicates the time taken by an AP for an imminent channel switch. The format of the element is defined in Figure 9-835 (Max Channel Switch Time element format).… (#11be)When the Max Channel Switch Time element is carried outside a Basic Multi-Link element, the Switch Time field indicates the time delta between the TBTT of the last Beacon frame transmitted by the AP in the current channel and the time by which the AP expects to have transmitted its first Beacon frame or (if applicable) broadcast unsolicited Probe Response frame, accounting for channel access delays in the new channel, and assuming that operation on the new channel is determined to be allowed, expressed in TUs. NOTE 1 – The last Beacon transmitted on the current channel is identified by the Channel Switch Count field equal to 1 or 0 in the (Extended) Channel Switch Announcement element. NOTE 2 – For instance, an AP switching to a channel subject to DFS-related regulatory requirements calculates the Switch Time field assuming that there is no DFS-related signal that would disallow operation on the new channel. When the Max Channel Switch Time element is carried in a Basic Multi-Link element, in the Per-STA Profile subelement corresponding to a reported AP that is not affiliated with an NSTR mobile AP MLD:* (#11be)until the last Beacon frame is sent on the current channel of the reported AP, the Switch Time field indicates the time delta between the TBTT of the last Beacon frame transmitted by the reported AP in its current channel and the time by which the reported AP expects to have transmitted its first Beacon frame or (if applicable) broadcast unsolicited Probe Response frame, accounting for channel access delays, in its new channel, and assuming that operation on the new channel is determined to be allowed, expressed in TUs.
* (#11be)after the last Beacon frame is transmitted on the current channel of the reported AP, the Switch Time field indicates the time delta, expressed in TUs, between the time the frame carrying the Basic Multi-Link element containing the Max Channel Switch Time element is transmitted by the reporting AP and the time by which the reported AP expects to have transmitted its first Beacon frame or (if applicable) broadcast unsolicited Probe Response frame, accounting for channel access delays, in the new channel, and assuming that operation on the new channel is determined to be allowed (see 35.3.11 (ML procedures for (extended) channel switching and channel quieting)).

(#11be)When the Max Channel Switch Time element is carried in a Basic Multi-Link element, in the Per-STA Profile subelement corresponding to a reported AP that is affiliated with an NSTR mobile AP MLD:* (#11be)the Switch Time field indicates the time delta, expressed in TUs, between the time the frame carrying the Basic Multi-Link element is transmitted by the reporting AP and the expected time that the reported AP resumes BSS operation on the new channel/class, assuming that operation on the new channel is determined to be allowed (see 35.3.19.3 (NSTR mobile AP MLD ML procedures for (extended) channel switching and channel quieting)).

A diagram of a channel switch  Description automatically generated |
| 11.8 DFS procedures 11.8.8 Selecting and advertising a new channel 11.8.8.2 Selecting and advertising a new channel in a non-DMG infrastructure BSSWhen an AP transmits an Extended Channel Switch Announcement frame or a frame containing a Channel Switch Announcement element or an Extended Channel Switch Announcement element, it should include a Max Channel Switch Time element in the frame if the Channel Switch Count field is nonzero and it may include the element if the field is 0. When the AP with dot11MaxChannelSwitchTimeEnhancedActivated not equal to true includes the Max Channel Switch Time element, the AP shall transmit the first Beacon frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element after the TBTT of the last Beacon frame transmitted in the current channel, unless the AP determines that it is unable to operate on the new channel. When the AP with dot11MaxChannelSwitchTimeEnhancedActivated equal to true includes the Max Channel Switch Time element, the AP shall transmit a first Beacon frame or broadcast unsolicited Probe Response frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element after the TBTT of the last Beacon frame transmitted in the current channel, unless the AP determines that it is unable to operate on the new channel....A STA that has dot11MaxChannelSwitchTimeEnhancedActivated not equal to true and receives a Channel Switch Announcement element may choose not to perform the specified switch, but to take alternative action. NOTE <**Editor to assign and renumber notes accordingly**>—As an alternative to performing the specified channel switch, the STA might choose to move to a different BSS.A non-AP STA that has dot11MaxChannelSwitchTimeEnhancedActivated equal to true and receives a Channel Switch Announcement element in a frame from its associated AP should perform the specified switch. A non-AP STA that has dot11MaxChannelSwitchTimeEnhancedActivated equal to true, that receives a Channel Switch Announcement element from its associated AP and that will not perform the specified switch, should take alternative action such as performing FT or disassociating before the start of the channel switch.A STA that receives a Max Channel Switch Time element from its associated AP should not transmit a frame to the AP on the new channel until it receives a frame on the new channel from the AP.NOTE 2—Whether or not a Max Channel Switch Time element is included, regulations might forbid a STA from transmitting on the new channel until it receives an enabling signal (e.g., a Beacon frame or broadcast unsolicited Probe Response frame). If a non-AP STA that has dot11MaxChannelSwitchTimeEnhancedActivated equal to true receives, from its associated AP, a Max Channel Switch Time element in the same frame as the Channel Switch Announcement element and is performing the indicated channel switch, the STA should attempt to receive frames on the new channel: * as soon as possible, if the Switch Time field in the Max Channel Switch Time element indicates less than one beacon interval, or
* one beacon interval before the time indicated by the Switch Time field in the Max Channel Switch Time element elapses, otherwise

If the STA receives at least one Probe Response or Beacon frame on the new channel from the AP, and * If, based on the received timestamp(s), the STA determines that the BSS has not been stopped and started during the channel switch, then the STA should not perform authentication and association in response to the completed channel switch and rather should continue its existing association.
* If, based on the received timestamp(s), the STA determines that the BSS has been stopped and started during the channel switch, then the STA should attempt to associate to the AP.
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| 11.9 Extended channel switching (ECS) 11.9.3 Selecting and advertising a new channel and/or operating class 11.9.3.2 Selecting and advertising a new channel in an infrastructure BSSWhen an AP transmits an Extended Channel Switch Announcement frame or a frame containing a Channel Switch Announcement element or an Extended Channel Switch Announcement element, it should include a Max Channel Switch Time element in the frame if the Channel Switch Count field is nonzero and it may include the element if the field is 0. When the AP with dot11MaxChannelSwitchTimeEnhancedActivated not equal to true includes the Max Channel Switch Time element, the AP shall transmit the first Beacon frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element after the TBTT of the last Beacon frame transmitted in the current channel, unless the AP determines that it is unable to operate on the new channel. When the AP with dot11MaxChannelSwitchTimeEnhancedActivated equal to true includes the Max Channel Switch Time element, the AP shall transmit a first Beacon frame or broadcast unsolicited Probe Response frame in the new channel no later than the time indicated in the Switch Time field of the Max Channel Switch Time element after the TBTT of the last Beacon frame transmitted in the current channel, unless the AP determines that it is unable to operate on the new channel.…When a STA with dot11DSERequired not equal to true and dot11MaxChannelSwitchTimeEnhancedActivated not equal to true receives an Extended Channel Switch Announcement element, it may choose not to perform the specified switch, but to take alternative action. NOTE <**Editor to assign and renumber notes accordingly**>—As an alternative to performing the specified channel switch, the STA might choose to move to a different BSS.A non-AP STA that that has dot11DSERequired not equal to true, dot11MaxChannelSwitchTimeEnhancedActivated equal to true and receives an Extended Channel Switch Announcement element in a frame from its associated AP should perform the specified switch. A non-AP STA that has dot11DSERequired not equal to true, dot11MaxChannelSwitchTimeEnhancedActivated equal to true, that receives an Extended Channel Switch Announcement element from its associated AP and that will not perform the specified switch, should take alternative action such as performing FT or disassociating before the start of the channel switch.A STA that receives a Max Channel Switch Time element from its associated AP should not transmit a frame to the AP on the new channel until it receives a frame on the new channel from the AP.NOTE 1—Whether or not a Max Channel Switch Time element is included, regulations in certain regulatory domains might forbid a STA from transmitting on a new channel until it has received an enabling signal (e.g., a Beacon frame or broadcast unsolicited Probe Response frame).If a STA that has dot11DSERequired not equal to true and dot11MaxChannelSwitchTimeEnhancedActivated equal to true receives, from its associated AP, a Max Channel Switch Time element in the same frame as the Extended Channel Switch Announcement element and is performing the indicated channel switch, the STA should attempt to receive frames on the new channel:* as soon as possible if the Switch Time field in the Max Channel Switch Time element indicates less than one beacon interval, or
* one beacon interval before the time indicated by the Switch Time field in the Max Channel Switch Time element elapses, otherwise

If the STA receives at least one Probe Response or Beacon frame on the new channel from the AP, and * If, based on the received timestamp(s), the STA determines that the BSS has not been stopped and started during the channel switch, then the STA should not perform authentication and association in response to the completed channel switch and rather should continue its existing association.
* If, based on the received timestamp(s), the STA determines that the BSS has been stopped and started during the channel switch, then the STA should attempt to associate to the AP.
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| C.3 MIB detailDot11StationConfigEntry ::= SEQUENCE{ …dot11DSERequired TruthValue,dot11ExtendedChannelSwitchActivated TruthValue,**…**dot11CIPActivated TruthValue(#M7),dot11MaxChannelSwitchTimeEnhancedActivated TruthValue}…dot11CIPActivated OBJECT-TYPE(#M7)SYNTAX TruthValueMAX-ACCESS read-writeSTATUS currentDESCRIPTION"This is a control variable.It is written by an external management entity or the SME.Changes take effect as soon as practical in the implementation. This attribute indicates whether or not CIP is enabled."DEFVAL { false }::= { dot11StationConfigEntry 248 }dot11MaxChannelSwitchTimeEnhancedActivated OBJECT-TYPESYNTAX TruthValueMAX-ACCESS read-writeSTATUS currentDESCRIPTION"This is a control variable.It is written by the SME or external management entity.This attribute, when true, indicates that the capability of the station to perform enhanced channel switching with Max Channel Switch Time is enabled; otherwise the capability of the station to perform enhanced channel switching with Max Channel Switch Time is not enabled."DEFVAL { false }::= { dot11StationConfigEntry 249 } |