BIGAP - A Seamless Handover Scheme for High Performance Enterprise IEEE 802.11 Networks

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Motivation

- Clear trend towards deploying dense IEEE 802.11 wireless networks (WiFi) in enterprise environments.
- Appearance of WiFi-enabled smartphones/tablets requires much better mobility support and higher QoS/CoE.
- Although, mobile clients in a dense WiFi network can choose from many possible APs, this "degree of freedom" is not fully exploited in 802.11 resulting in restricted mobility.
- Clients decide on handover (HO) operation using just local information.
- There is a need for providing methods for infrastructure-initiated handover scheme which would allow the design of novel seamless mobility and client load balancing schemes.

BIGAP's Design Principles

- The DenseAP HO [1] enables infrastructure-initiated HO without requiring any modifications in existing client devices.
- But it creates a severe network outage during HO caused by the amount of time the STA needs for the connection build-up with the new AP (scanning, probing, authentication and re-association).
- Proposed BIGAP [2] decreases the network outage duration and removes all delays by transferring the current state of the STA from the serving AP to the target AP.
- BIGAP topology uses a single global BSSID for the whole ESS and thereby for all APs.
- From STAs point of view, the whole ESS including all APs seems like one ESS or one big AP.
- BIGAP uses different RF channels for all co-located APs to avoid packet collisions.
- BIGAP exploits the 802.11 DFS functionality and leads the STA to believe that the serving AP will perform a RF channel switch due to a detected radar signal.
- But serving AP remains on its RF-channel whereas the target AP is operating on the new channel.
- As all APs use the same BSSID and the current state of the STA on the old AP was transferred to the new AP, the STA believes the new AP is the old AP which has also switched the RF channel.
- Communication can be continued without any further outage except the time needed for channel switching in client device.
- BIGAP works with unmodified STAs, i.e. support of 802.11ac is sufficient.
- BIGAP requires the existence of a sufficient large number of available RF channels so that different channels can be assigned to co-located APs (6 GHz band 9/25 channels).

Illustrative example shows the steps to perform a HO of STA from AP1 to AP2.

1. A decision was made in the BIGAP controller to handover STA from AP1 to AP2.
2. The traffic flows towards STA need to be routed over AP2.
3. The BIGAP controller associates and authenticates STA on the target AP, AP2, using the information about STA provided by AP1. This makes sure that after the handover operation the STA is properly registered within AP2 since otherwise AP2 would respond with a disassociation frame and will not accept data frames.
4. BIGAP controller instructs AP1 to send out a unicast beacon containing a CSA-IE with the channel set to the target AP, here 2, destined to STA.
5. On successfully receiving the unicast beacon containing the CSA-IE the corresponding STA performs channel switching as specified in the IEEE 802.11 standard.
6. Since both AP1 and AP2 have the same BSSID, aka MAC address, the STA does not notice that it is being served after the channel switch by another AP, AP2. STA continues with its communication.

Seamless Mobility with BIGAP

- Seamless mobility using BIGAP - architecture & steps involved

Demo Setup

- The objective is to show that BIGAP supports seamless HO, i.e. preserves a good user experience in mobility and load-balancing scenarios.
- Demonstration setup consists of three components: (i) BIGAP controller, (ii) two APs and (iii) two client STAs (unmodified smart-phone/tablet running Android)
- BIGAP was configured to perform periodic HO operations:
  - Every 30s each client is handed over from one AP to the other.
  - Direct comparison: STA1 is using the proposed BIGAP soft HO scheme whereas STA2 is handed over by the hard handover.
  - For each client STA two traffic flows are set-up:
    1. ICMP ping showing the round-trip time (RTT) from the controller to the client, and
    2. An unbuffered UDP video stream sent from the controller to the STA.
- The audience can observe:
  - That during the BIGAP soft HO operation the quality of the video stream is not negatively affected, i.e. judder-free motion without artifacts.
  - In parallel as a direct comparison the standard hard HO shows significant juddering and artifacts.
  - This observation can be confirmed by the plots illustrating the RTT and packet loss of the ICMP flows.
  - With the BIGAP soft handover, the RTT is only slightly affected with just occasional packet losses which is not the case with hard HO, i.e. bursts of packet losses with durations of several seconds.

Results

- Selected results from experiments in indoor testbed:
  - Network outage duration due to handover
  - BIGAP handover - throughput vs. time
  - Demo setup, enables direct comparison between BIGAP soft-handover and standard hard-handover scheme.

References