End to End Principle in Access Point Selection

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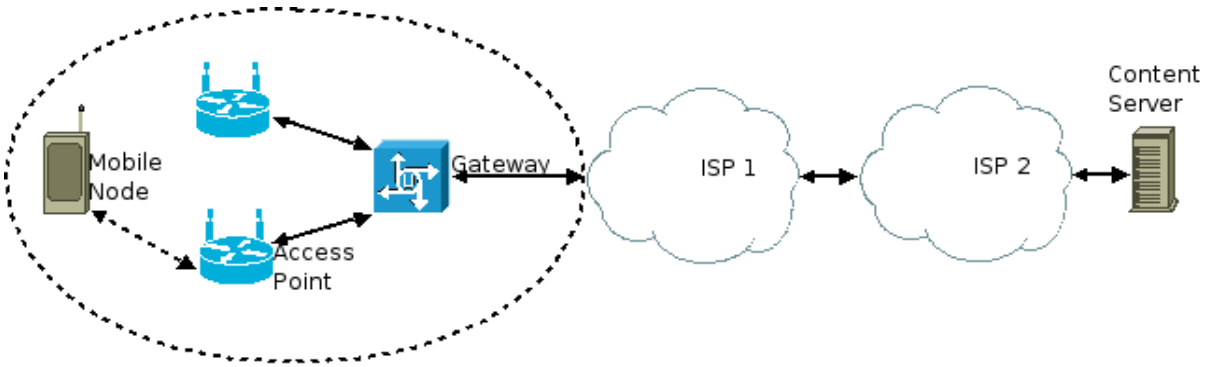
Introduction

- Intelligent (WLAN) Access Point (AP) selection methods have been studied extensively in the recent years
- Most of the existing studies have focused on AP selection decision making close to the Mobile Node (MN)
- The existing concepts can roughly be classified into two categories
  - Concepts that require changes to the network's components
  - Concepts that propose that the MN should select the most suitable AP for itself based on measurements it has conducted



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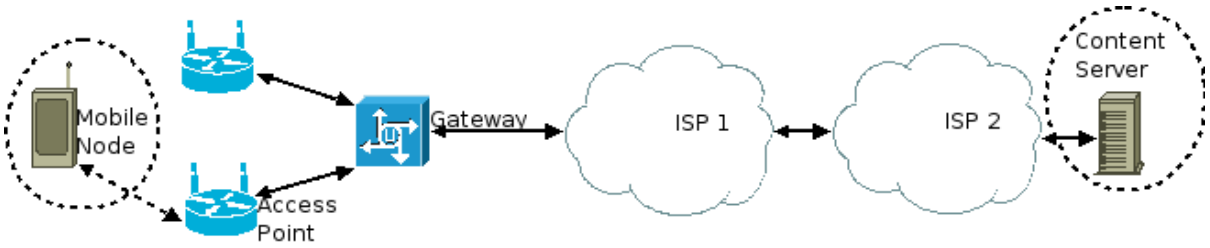
Concept

- We present a concept that doesn't fall into either of the two existing AP selection categories
- Instead, we propose that part of the AP decision making logic is pushed to the Content Server (CS)
- MN and the CS co-operatively decide the most suitable AP for content delivery
- The network(s) are treated as black boxes



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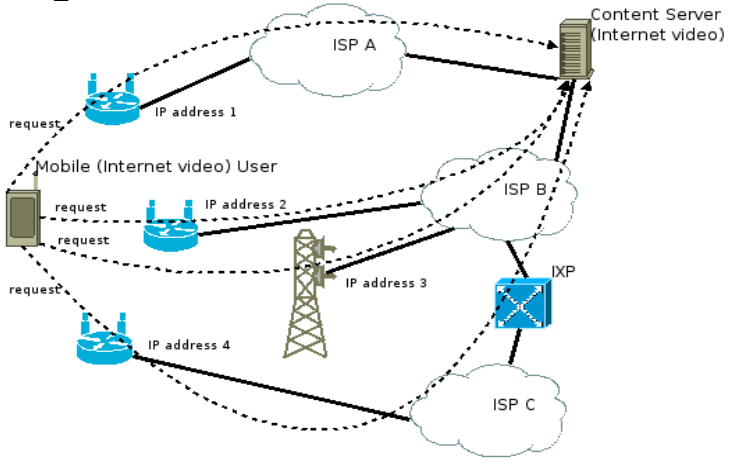
New AP selection process

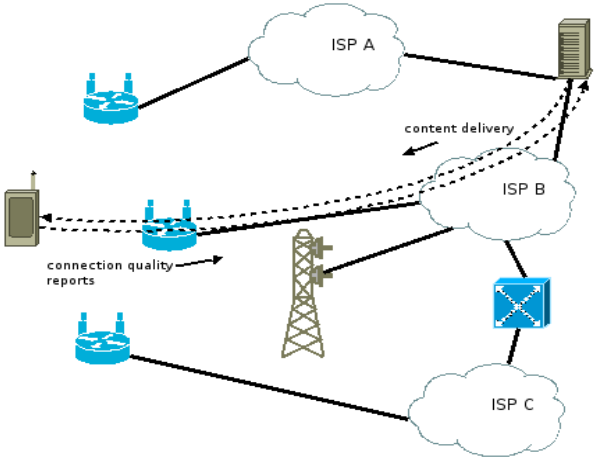
- Pre-selection of APs is done by the MN
  - If MN is moving quickly, it shouldn't use WLAN APs
  - Otherwise, it should (pre)use all APs
- MN measures local parameters for all pre-selected APs, and sends a request via all of them to the CS
  - MAC addresses of APs are added to requests – used to identify the APs
- CS selects the most suitable AP and delivers the content via it

1.



2. Content Server decides the best Access Point (IP address 2)

3.



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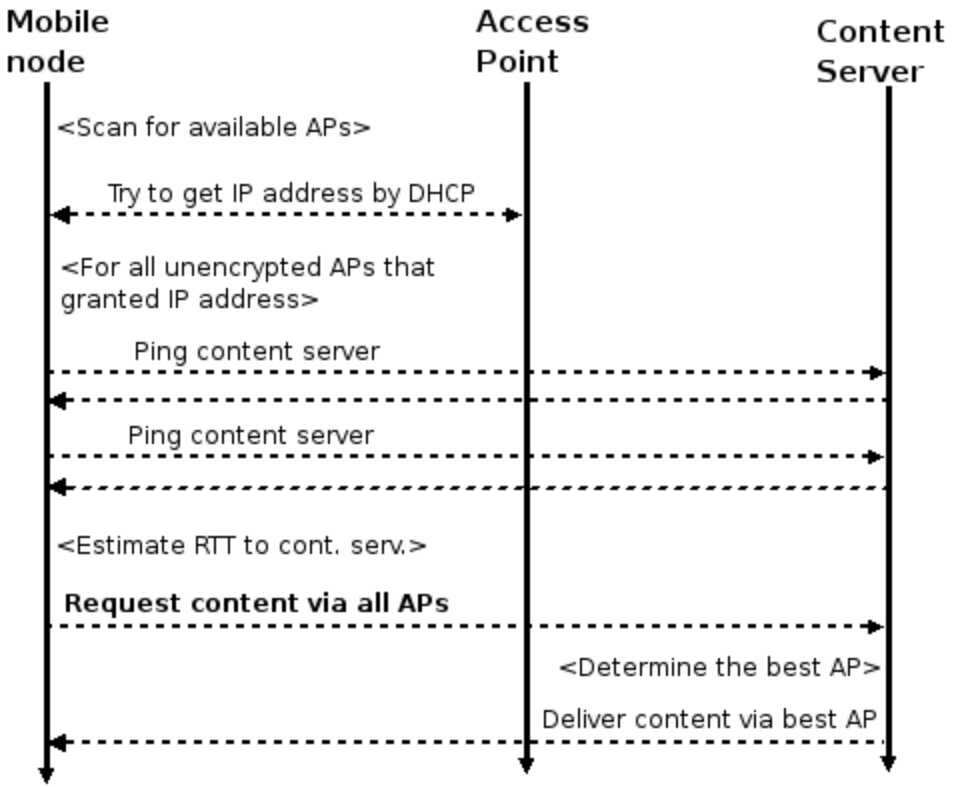
Flowchart

- Rules such as: fast moving MNs should prefer cellular APs over WLAN APs, a MN should not choose an over-utilized AP, MNs should prefer APs with high-capacity uplinks, are used
- This way the users will be happier with the content provider's service, which will benefit both the provider and the user
- Also ISPs will have an incentive to improve their networks so that their networks will be chosen for the content delivery



Attributes that affect the AP selection

- The pieces of information present in the requests that MN sends to CS via all of the APs that granted IP (and were pre-selected) are:
  - Signal strength of the AP (Signal Strength Indicator)
  - Potential downstream bandwidth for AP (AP utilization)
    - Determined by the MN from beacon intervals
  - RTT to the CS via this AP (+jitter)
  - Uplink bandwidth of AP (if this information can be found in the beacons that the AP broadcasts)
- Also the CS considers the following piece of information:
  - Date and time of day (historical database)

AP selection

- Suppose that a MN has sent content requests to the CS via corresponding APs
- Each of the requests contains a set *S* of metric values characterizing the benefit of using the corresponding AP to deliver the content to the MN
- Now the CS must find the best *S* among the requests that the MN has sent so that the most suitable AP can be determined
- Best *S* is one for which the path via the corresponding AP will maximize the QoE of the user during the content delivery

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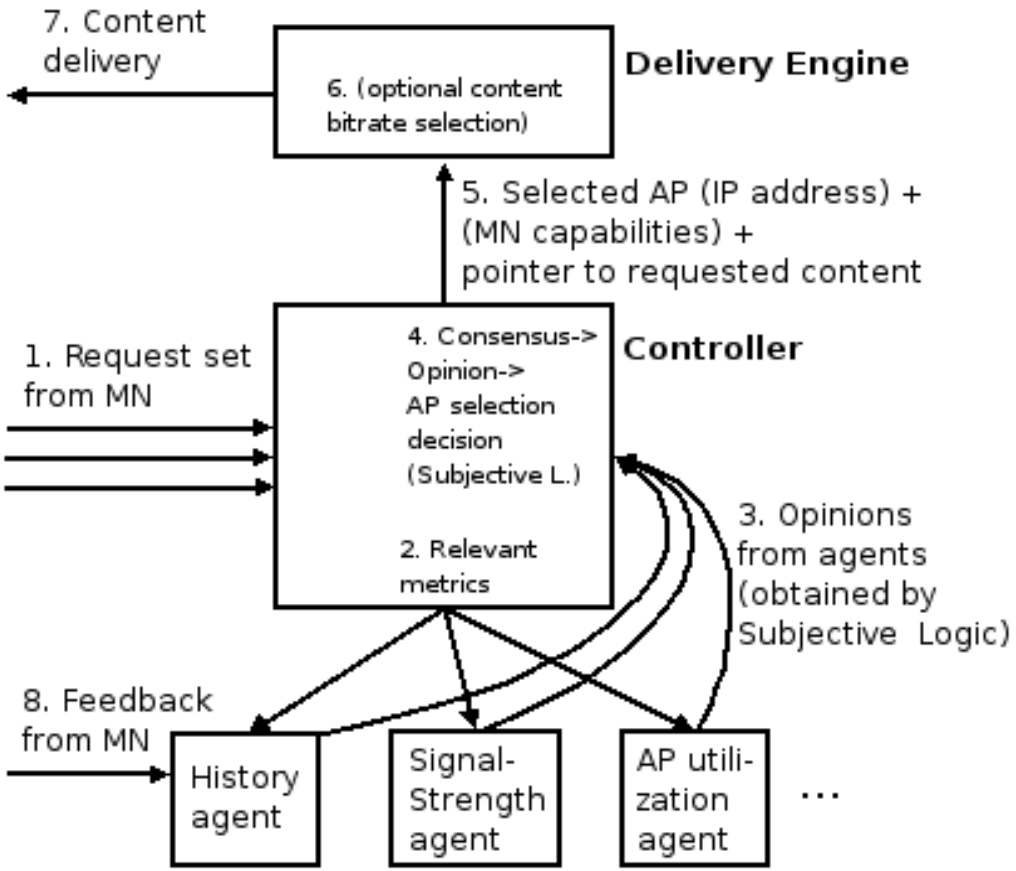
AP selection (cont)

- Each of the agents presented in Figure 5 calculates its own *opinion* about the quality of the APs based on the metrics found in the requests, and delivers this opinion back to the Controller-module
- The Controller utilizes the *consensus*-operator from subjective logic to form combined opinions regarding the APs



Subjective logic

- In general, subjective logic is suitable for modeling and analyzing situations involving uncertainty and incomplete knowledge
- *Opinion* of an agent (for instance, opinion that a certain AP will provide a MOS score above a treshold) is represented by *belief*, *disbelief*, *uncertainty*, and *atomicity*
- *Consensus* operator of Subjective Logic can be used to form a combined opinion from multiple opinions

The reporting functionality

- When the CS has decided to deliver the content via a certain AP, the data starts flowing
- MN should send report(s) back to CS about the quality of reception, so that the CS can update its database accordingly
- The report payload can be formed, for instance, by using the *Video Streaming Quality Index* (VSQI)
- The VSQI score is expressed as a MOS value (Mean Opinion Score) between 1 and 5

VSQI

- VSQI is based on research quantifying how quickly viewers lose patience during (re)-buffering events and how long it takes to restore their appreciation after normal replay has resumed
- The VSQI algorithm uses the following input:
  1. The quality of the encoded signal prior to transmission (function of the used video codec)
  2. The time required for initial buffering and for re-buffering (due to interruptions) during playback of the video sequence
  3. The amount of packet loss in the transport path
- Each VSQI score reflects the recent history of the streaming session: packet loss levels and possible buffering events.
- The MN may deliver the average VSQI score to the CS, for instance, once in every ten seconds or alternatively, at the end of transmission

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