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Wi-Fi Internet connectivity and privacy: hiding your tracks on the wireless Internet

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- **Introduction**

- **Background and Problem Statement**

- **Layer-2 Address Randomization**

  - **Experimental Evaluation**

  - **Context-aware Address Randomization**

- **Standardization Efforts**

- **Conclusions and Future Work**

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◆ **Internet privacy is becoming a huge concern**

◆ **Wireless users can be easily tracked**

◆ **Privacy issues affect all protocol layers**

◆ **We focus on threats at the connectivity level**

  ❖ **Layer-2 and Layer-3**

◆ **Layer-2 address randomization**

  ❖ **Experimentally assessed during IETF meetings**

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◆ **IEEE 802-based interfaces are easy to track**
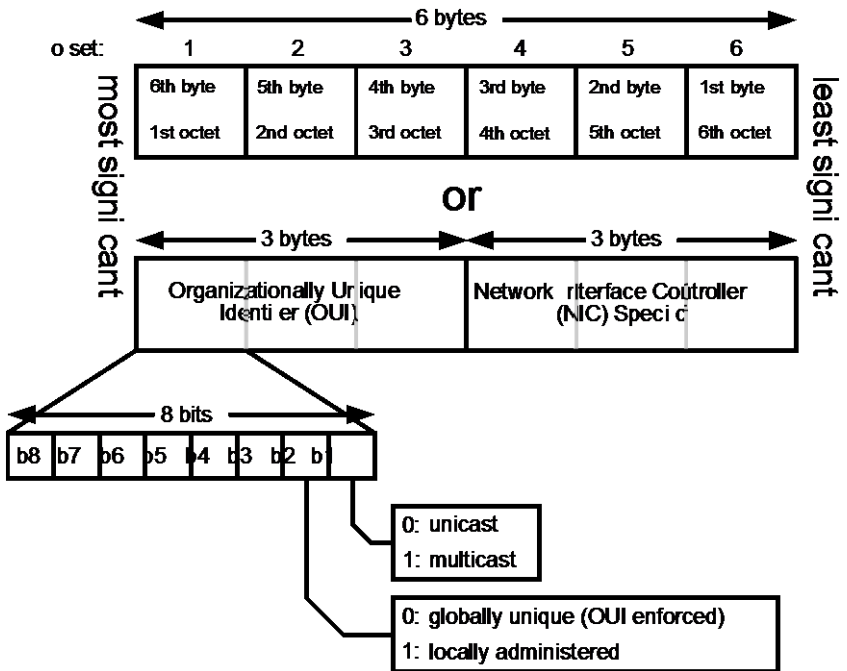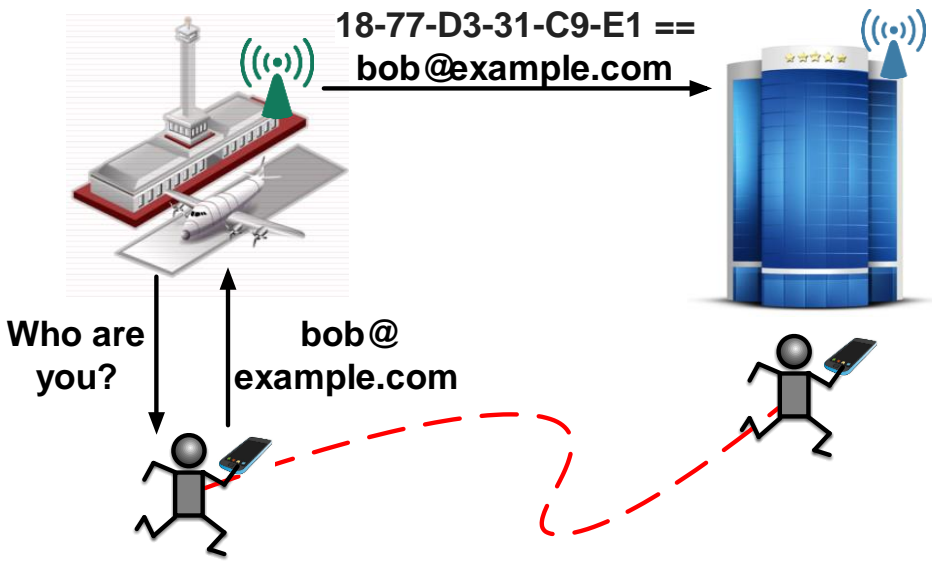
- ◆ **An IEEE 802.11 station exposes its L2 address**
  - ❖ **When actively scanning for available networks**
  - ❖ **Once associated, in frame TX & RX**
- ◆ **IPv6 address auto-configuration may make L2 identifiers visible to all L3 peers**
  - ❖ **Temporary addresses (RFC 4191)**
  - ❖ **Opaque IIDs (RFC 7217)**
- ◆ **These solutions do not solve all the problems**

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◆ **Randomizing the L2 address makes tracking more difficult**

◆ **We have experimentally validated and assessed it**

   ❖ **Analysis of existing OSes' support to conduct address randomization**

   ❖ **Evaluate its effect on users and the network**

   ❖ **Conducted experiments at IEEE and IETF meetings**

**https://oruga.it.uc3m.es/802-privacy/index.php/MAC address change tutorial**

6
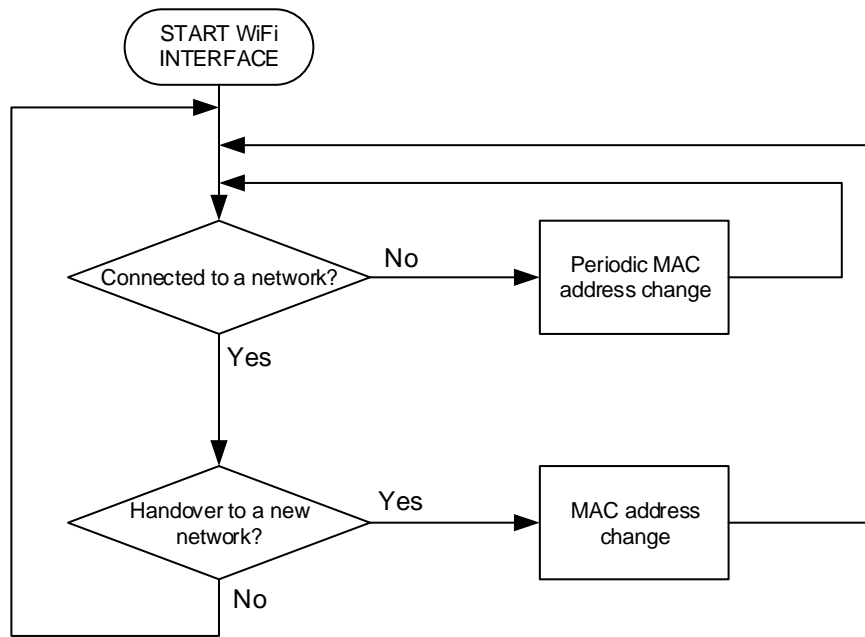
◆ **Real-life experiments during IETF meetings**

- ❖ **IETF 91: A specific SSID (`ietf-PrivRandMAC`) was deployed on the wireless Internet infrastructure**

- ❖ **IETF 92: Deployed on all IETF physical Access Points (no isolated ESSID)**

- ❖ **WLAN address randomization scripts developed and provided for 4 different OSes: Linux, Mac OS X, MS Windows and Android**

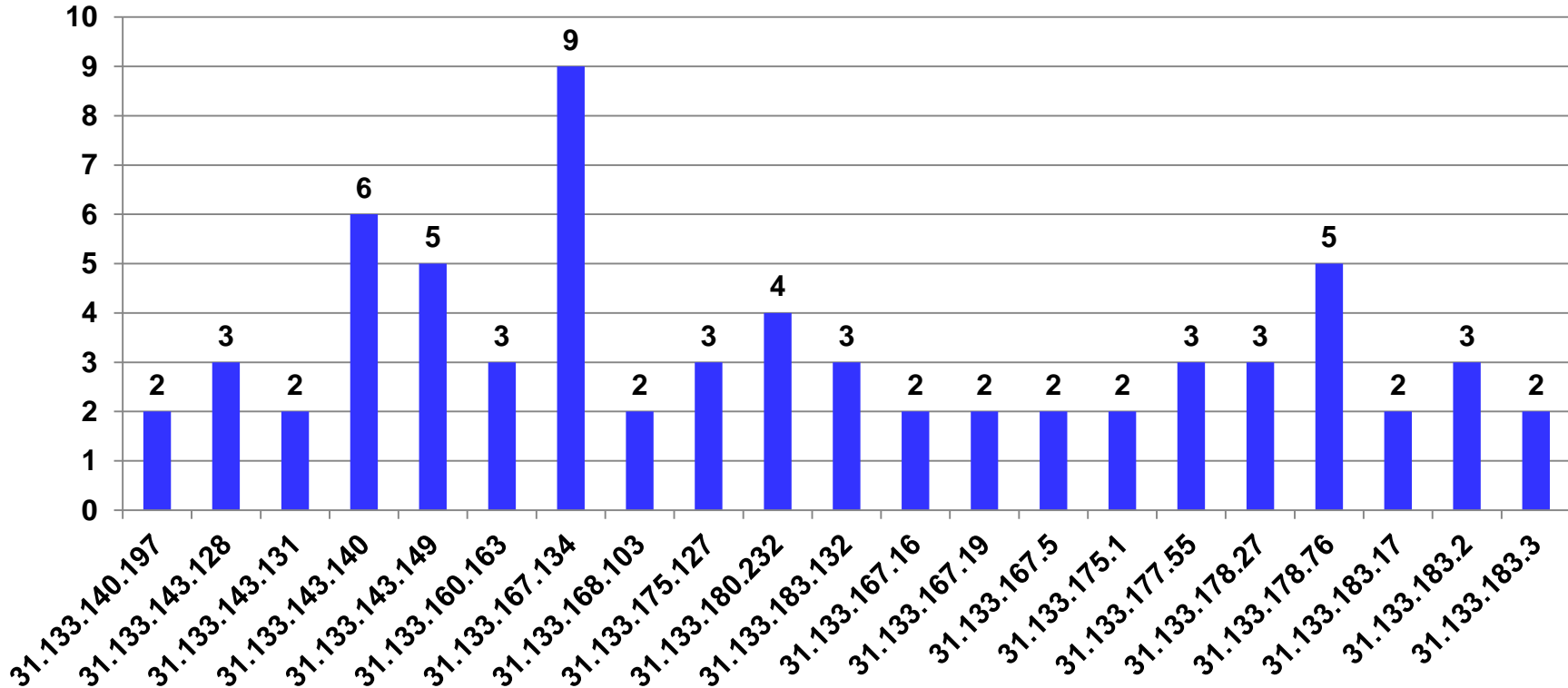- ❖ **Use of DHCP client identifier for debugging**

Experimental Evaluation (II)
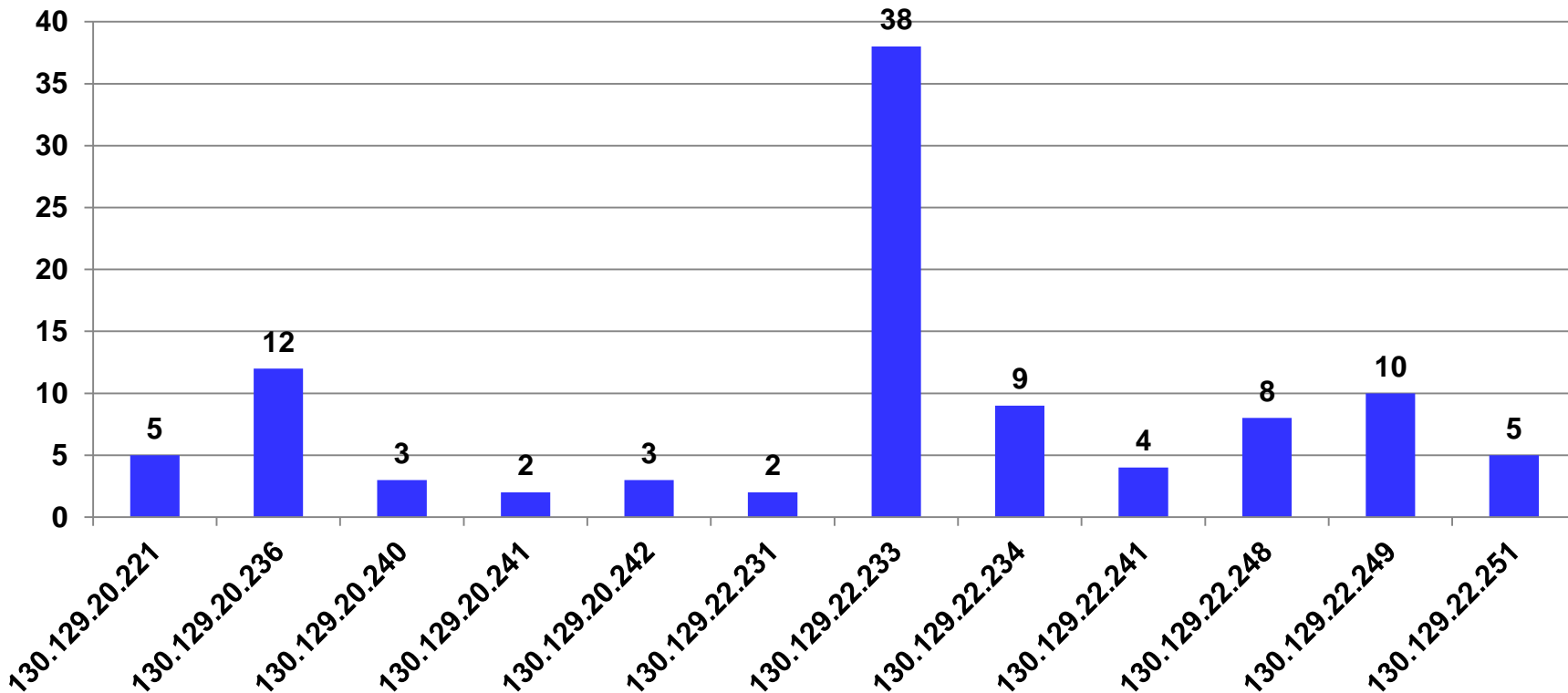
Number of MAC addresses per IP address, for those IPs that were assigned to multiple local MAC addresses (IETF 91)

Experimental Evaluation (III)

Number of MAC addresses per IP address, for those IPs that were assigned to multiple local MAC addresses (IETF 92)

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◆ **MAC addresses can also be leaked by other protocols (e.g., DNA)**

◆ **L2 address randomization is a powerful tool**

◆ **Always-on/off privacy policies are not enough**

  ❖ **Access lists based on L2 addresses**

◆ **Privacy configuration should be influenced by the context of the user**

  ❖ **E.g., visible networks, geo location, etc.**

- **Internet privacy is a priority item for the IETF, the Internet Architecture Board (IAB), and the Internet Society**
  - ❖ **IAB Statement on Internet Confidentiality**
  - ❖ **Privacy implications on DHCP protocols**
  - ❖ **Use of the hostname in different protocols**
- **IEEE 802 Privacy Executive Committee (EC) Study Group (SG) was created in July 2014**
  - ❖ **Specification work will be done in IEEE 802E**

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- ◆ **Privacy issues due to the use of L2 addresses**
- ◆ **L2 address randomization provides some mitigation against privacy**
- ◆ **Experiments conducted in large networks**
  - ❖ **Now permanent at IETF & IEEE 802 meetings**
- ◆ **Implementations in products**
  - ❖ **E.g.: Microsoft Windows 10, iOS 8 & 9**
- ◆ **Privacy tools should not work in isolation**

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