It's Not Where You Are, It's Where You Are Registered

IoT Location Impact on MUD

Anat Bremler-Barr David Hay Bar Meyuhas Shoham Danino

TEL AVIV UNIVERSITY

THE HEBREW UNIVERSITY OF JERUSALEM

Reichman University

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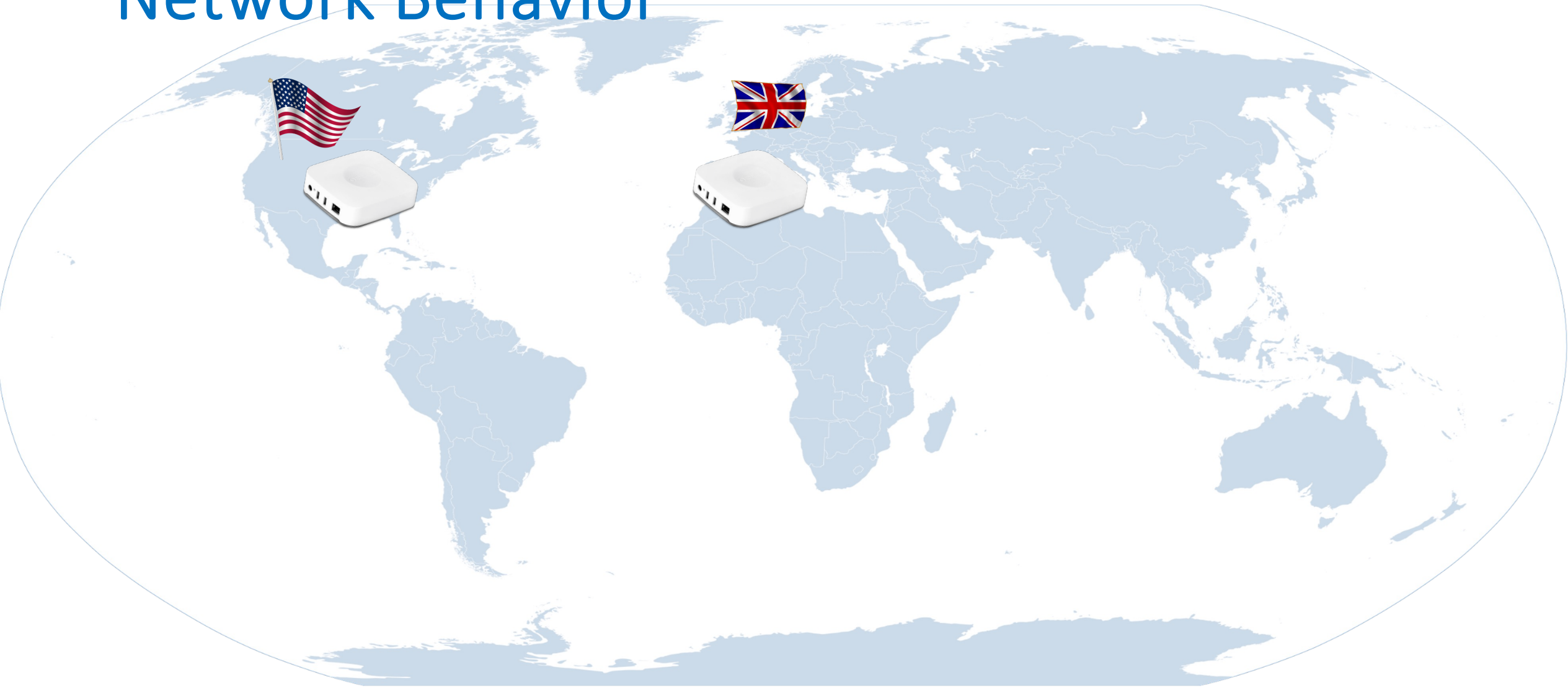
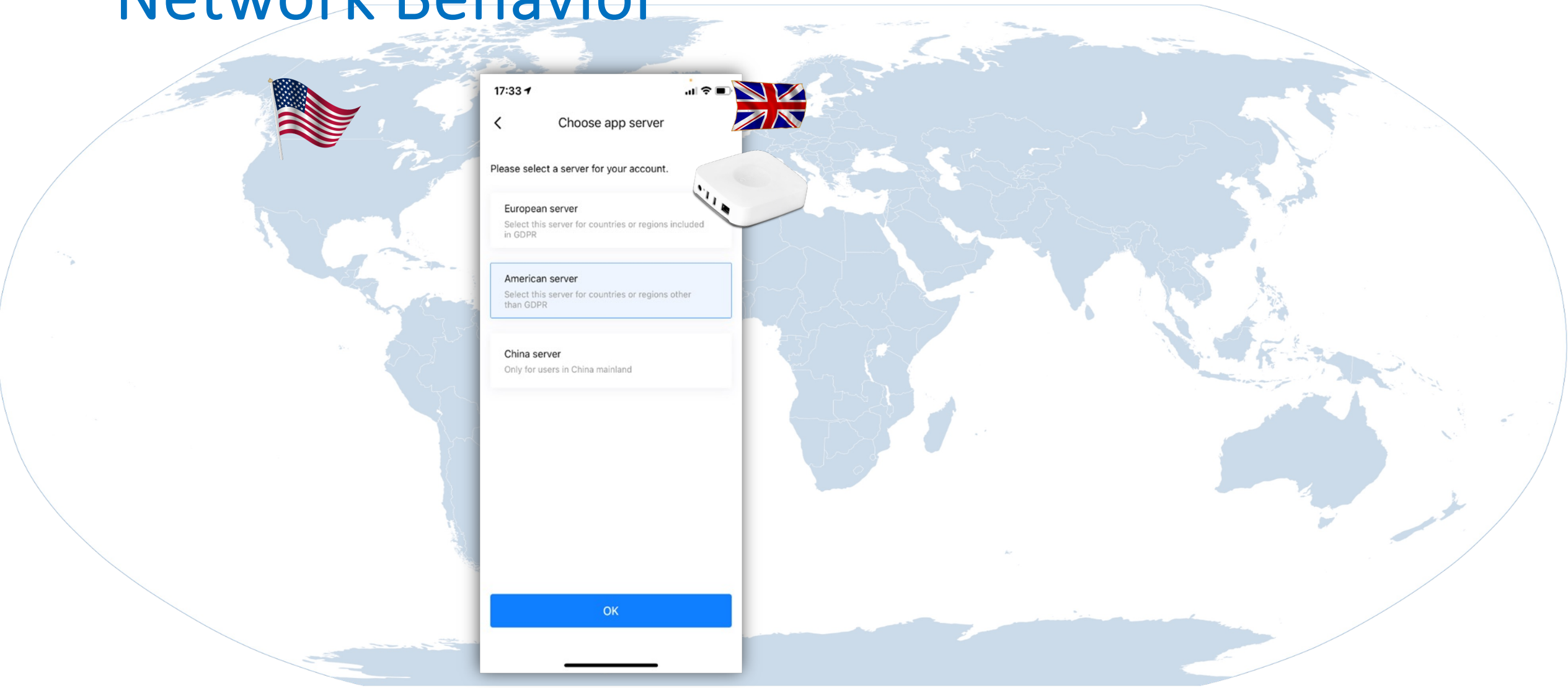
IP-based Location Impact the IoT Network Behavior



User-defined location Impact the IoT Network Behavior



Motivations

Implication on:

- Network security framework (MUD RFC 8520)
- IoT Identification

→ Learning normal device behavior and then extracting rules and features is affected

Outline

- IP-based location < user-defined location
- Common user-defined location implementation
- Background MUD – IETF security framework
- The implication of user-defined location on the MUD
- Improving implementation using DNS ECS

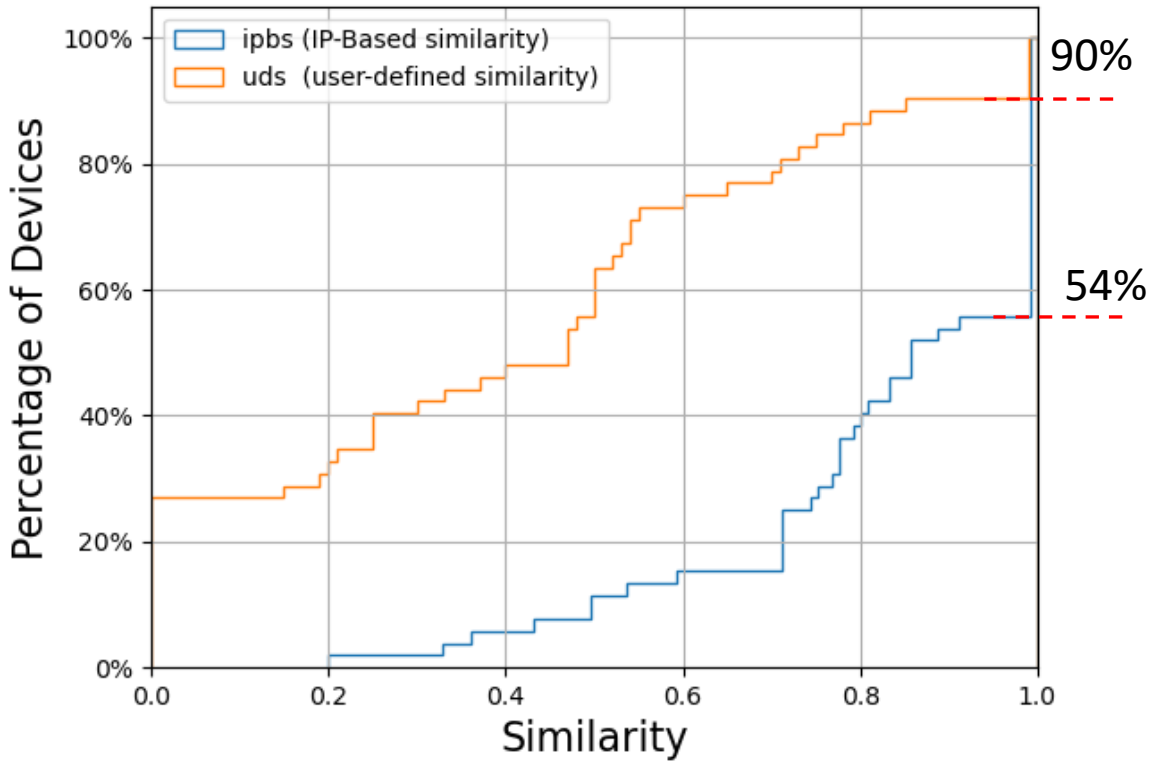
Location Impact is Very Common

The similarity measure of two set of domains for the same device d, at location i and location j is defined:

$$uds(d, i\ell, u\ell, u\ell') = \frac{|\mathcal{D}(d, i\ell, u\ell) \cap \mathcal{D}(d, i\ell, u\ell')|}{|\mathcal{D}(d, i\ell, u\ell) \cup \mathcal{D}(d, \ell, u\ell')|}$$

$$ipbs(d, u\ell, i\ell, i\ell') = \frac{|\mathcal{D}(d, i\ell, u\ell) \cap \mathcal{D}(d, i\ell', u\ell)|}{|\mathcal{D}(d, i\ell, u\ell) \cup \mathcal{D}(d, i\ell', u\ell)|}$$

CDF of MUD similarity measure values

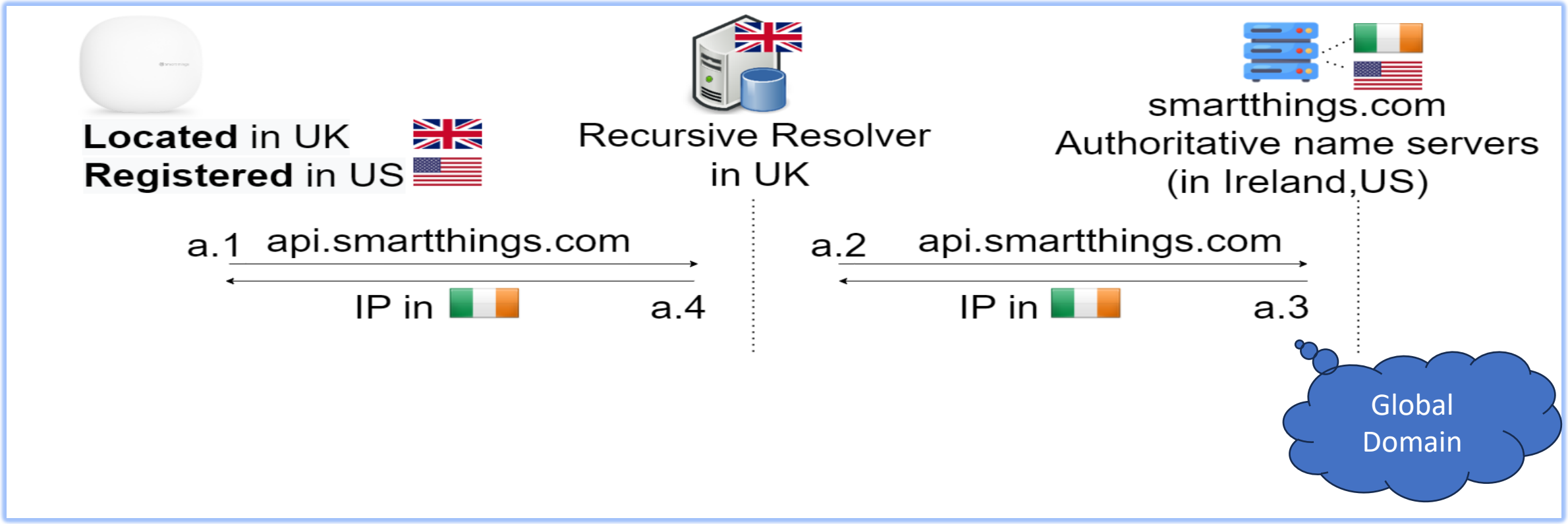


Why there is a difference in the domains?

- Different domain names allow different features and servers
- But there are other ways to implement different IPs for the same domain, for example using IP-based location

To allow USER-DECISION of location, the domain names must be different

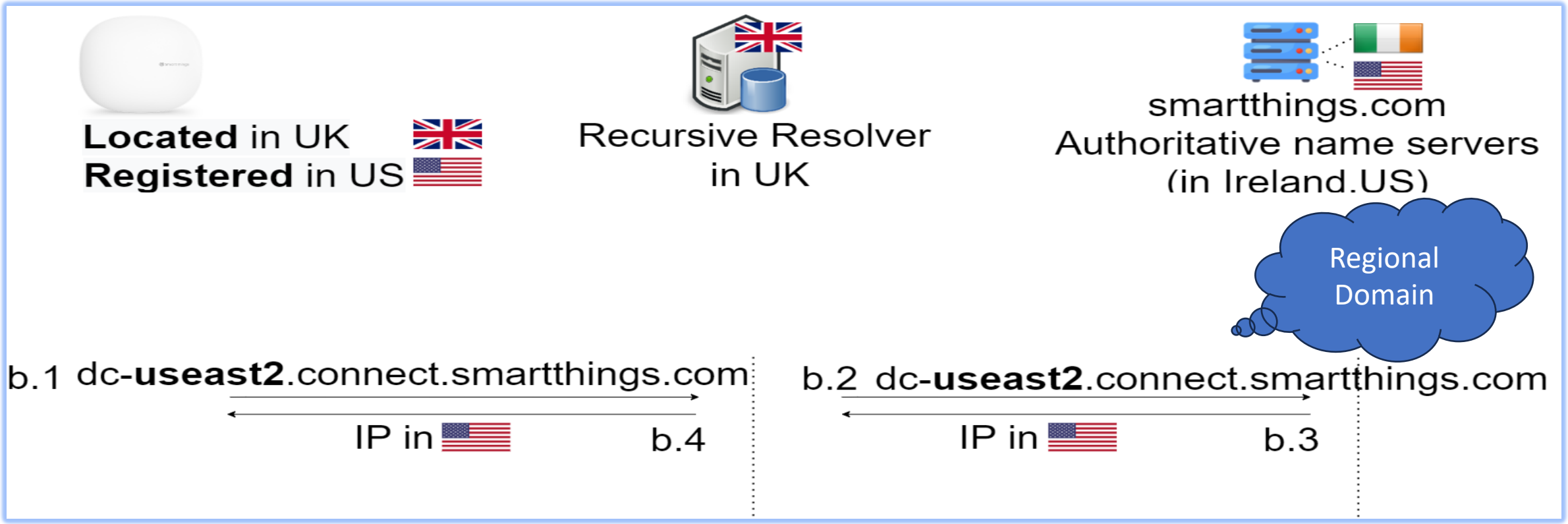
IP-Based Location Decision: DNS



User-Defined Location: US

IP Location: UK

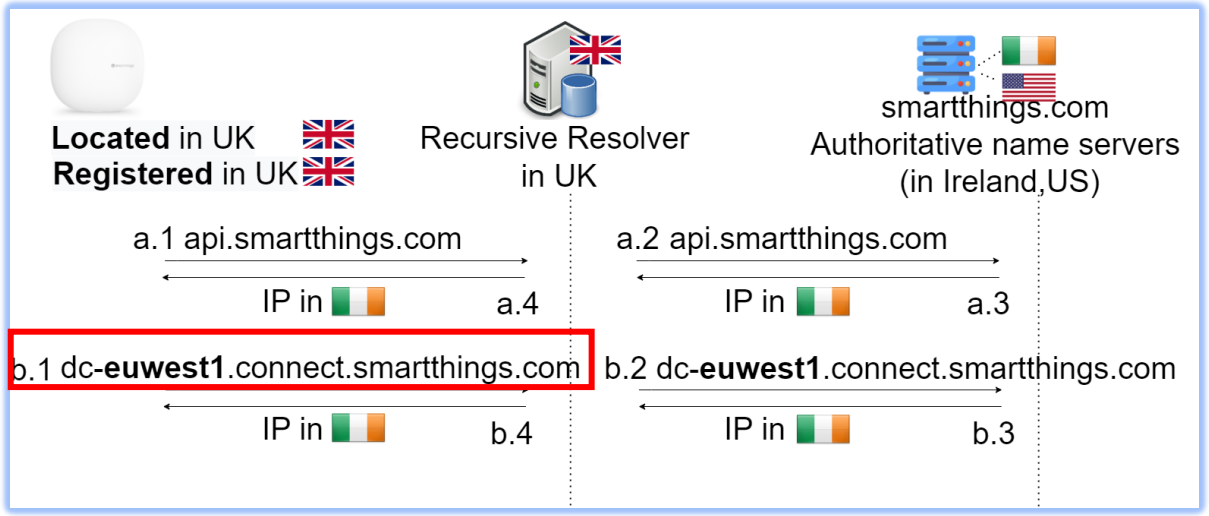
User-Defined Location Implementation

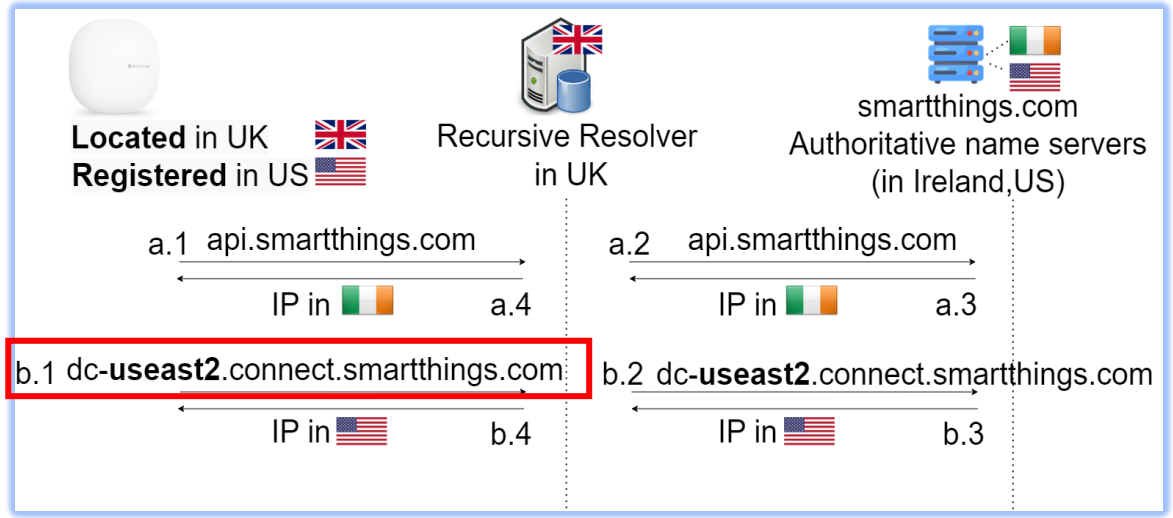


User-Defined Location: US

IP Location: UK

User-Defined Location Difference





User-Defined Location: UK

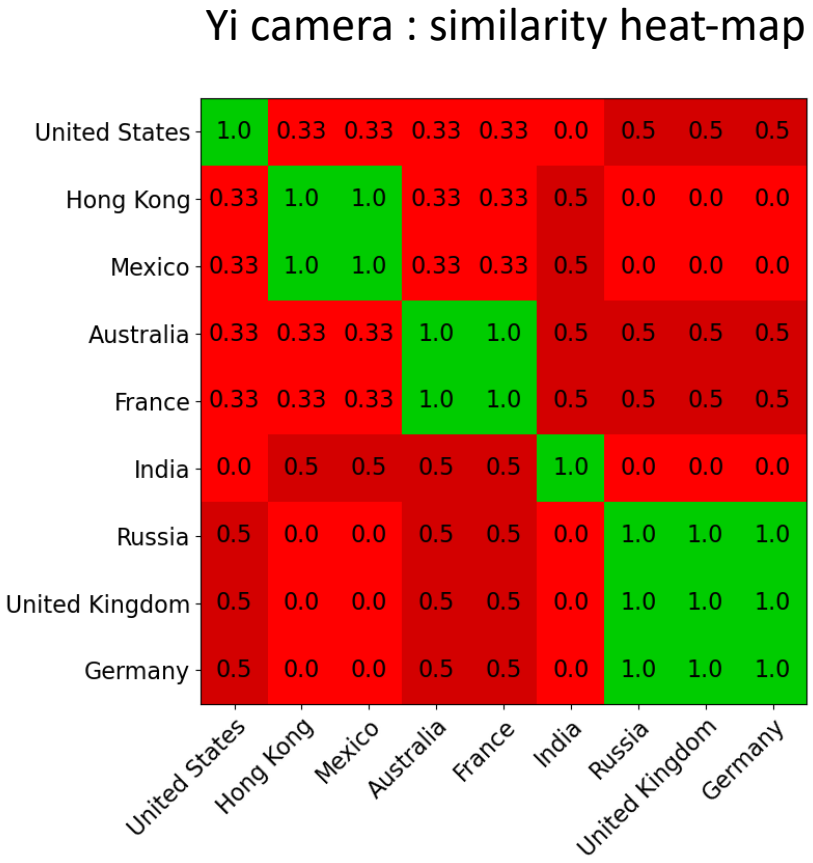
IP Location: UK

User-Defined Location: US

IP Location: UK

Regional domain changes: dc-**euwest1/useast2**.connect.smarthings.com
Global domain remains: api.smartthings.com

Correlation to Regions



Common case the differences in sub-domains

dc-euwest1.connect.smarthings.com
user-defined location in the UK

dc-useast2.connect.smarthings.com
user-defined location in the US

Only 9% of the domains present a difference in the Top-Level-Domain (TLD)

MUD Profile: network behavior formalization

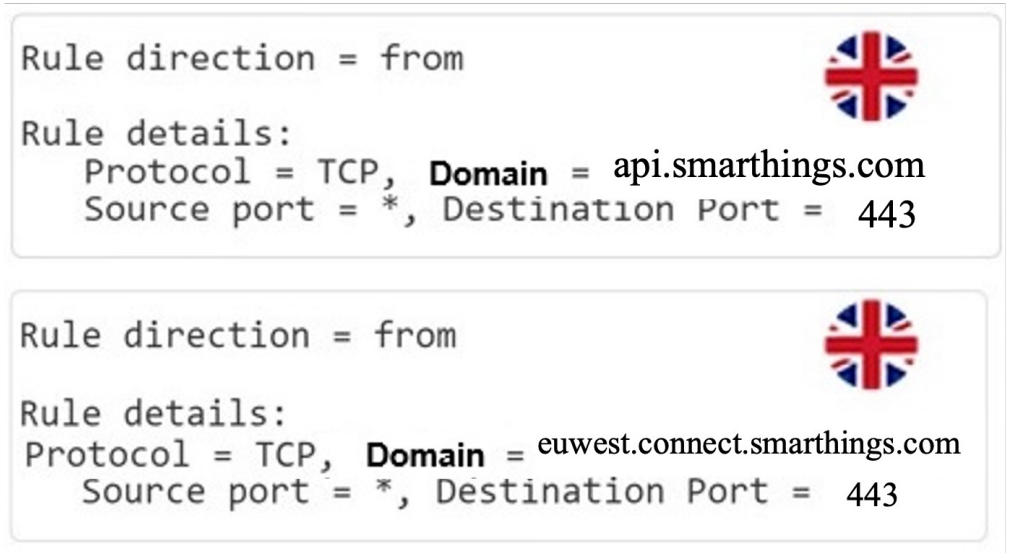
- IETF Standard, RFC 8520

- MUD file is an Access Control List (ACL), a set of Access Control Entries(ACEs)
  - *ACE = (Legitimate Endpoint, protocol, source port, destination port, direction)*
  - Legitimate endpoint is usually a **domain name** (or IP ,MAC)

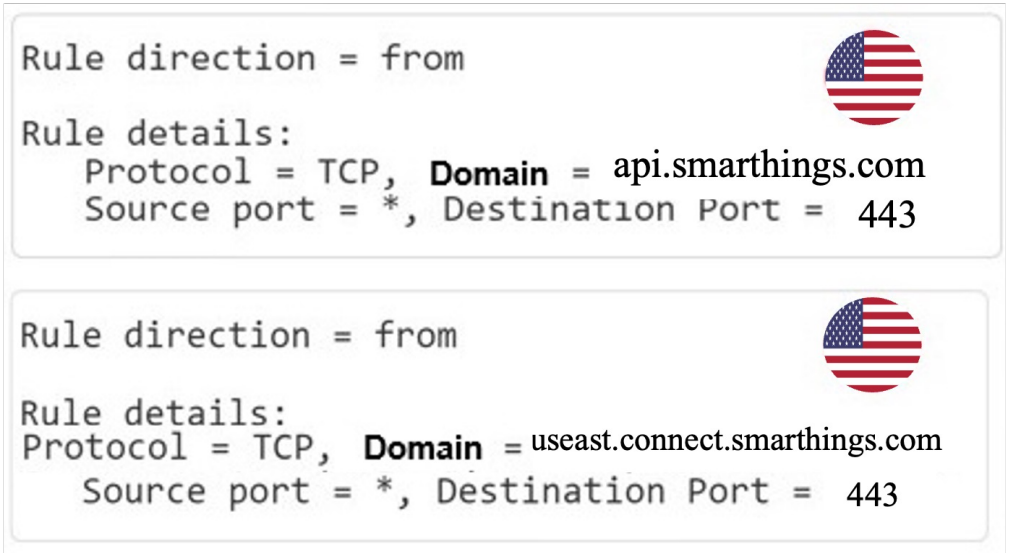
- Reduce attack surface
  - Allow-list IoT network behavior
  - Firewall allows only known network behavior

```
{
  "ace": [
    {
     "name": "from-ipv4-xiaomi-camera-Israel",
     "ipv4": {
       "protocol": 6,
       "ietf-acldns:dst-dnsname": "sg.ots.io.mi.com"
     },
     "tcp": {
       "destination-port": {
          "operator": "eq",
          "port": 443
       },
       "ietf-mud:direction-initiated": "from-device"
     }
    },
    {
     "actions": {
       "forwarding": "accept"
     }
    }
  ]
}
```

MUD Implication



UK MUD file



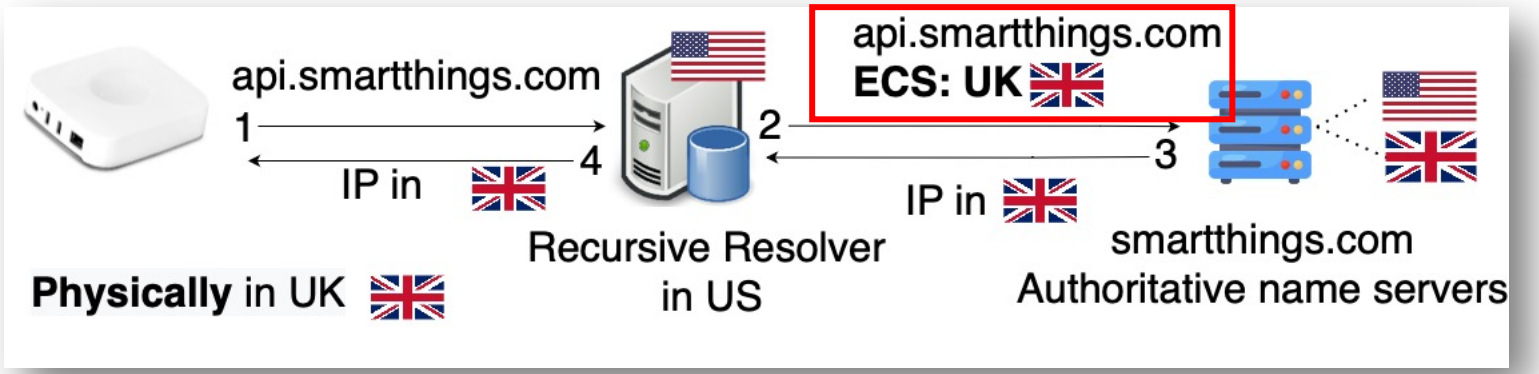
US MUD file

- Learning phase MUD
- Single large MUD vs separate MUD files
- Explainability & Maintenance

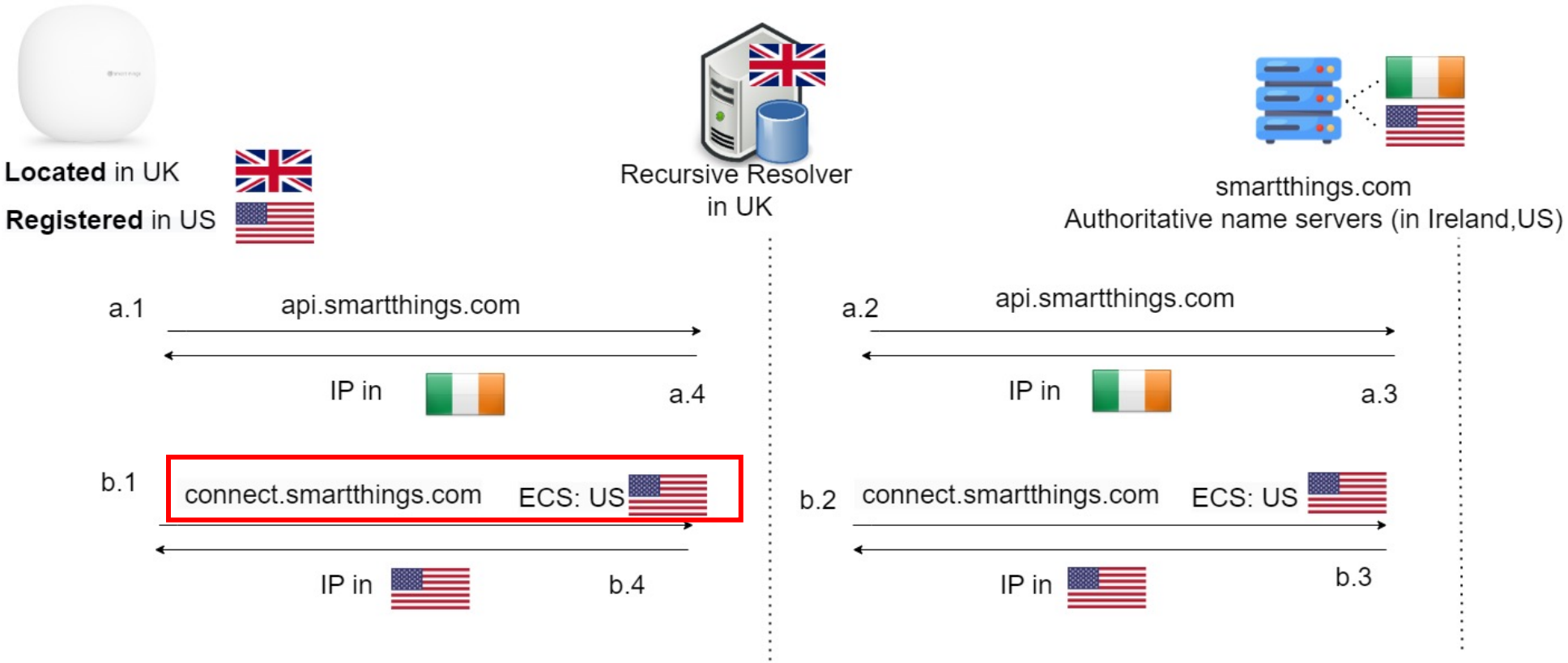
Extension DNS: ECS (Client Subnet)

- When using an open resolver, in which the resolver location is different than the client location. ECS can carry the client's IP.
- ECS RFC allows the end-point device to send an ECS field.

EDNS Client subnet - Current implementation

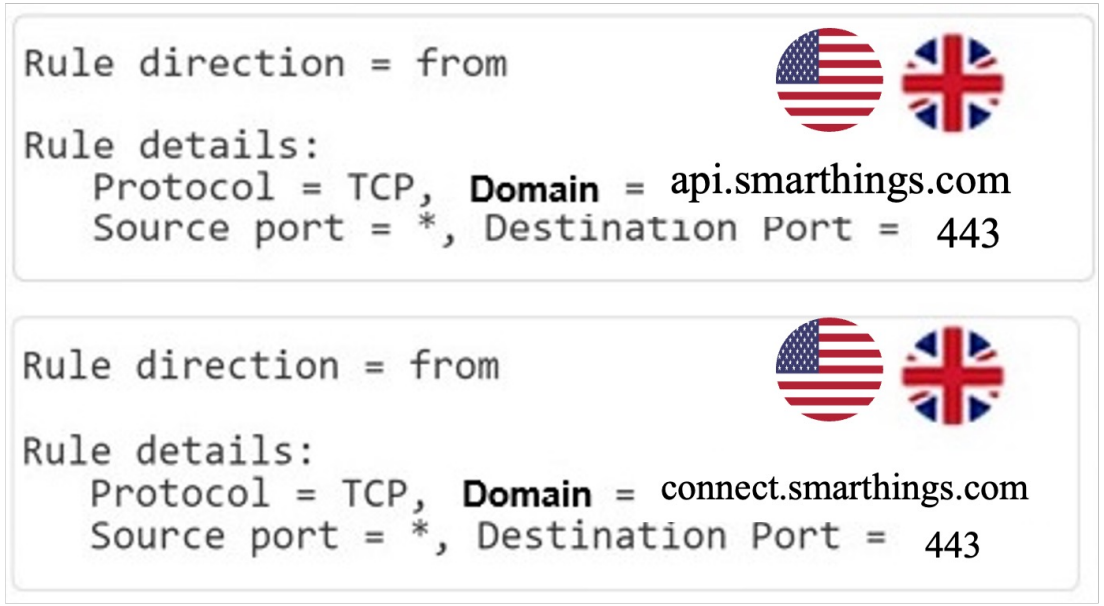


Our proposal: using DNS ECS to carry the USER-DECISION



In our ECS-based user-defined location, the IoT device, and not the resolver, will add the ECS. Regional domains carry an ECS field while global domains do not.

MUD Using ECS



- Learning phase MUD – easier
- Single MUD
- Explainability & Maintenance

Conclusion

User-defined location has an impact on IoT device network behavior

Dataset and security measurement should take location into account

User-defined can be implemented using the extension DNS

For more information on our IoT research

http://www.deepness-lab.org/Iotica

Questions: meyuhas.bar@post.idc.ac.il

dhay@cs.huji.ac.il

mrdaninos@gmail.com

bremler@idc.ac.il