July 11, 2025
COMPSAC/SAPSE2025 Workshop, Toronto

Offline Attribute Sharing Methods for Authentication Traffic Reduction and Functionality Enhancement of Wireless LAN Roaming Systems

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Secure Wireless LAN Roaming

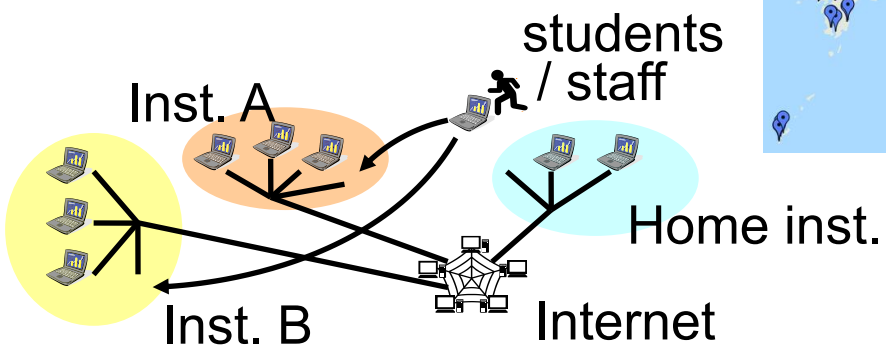
- Wi-Fi roaming systems allow users to join wireless networks at various places even across different operators.
- No need for cumbersome sign-up.

eduroam

for Research&Education (2002-)

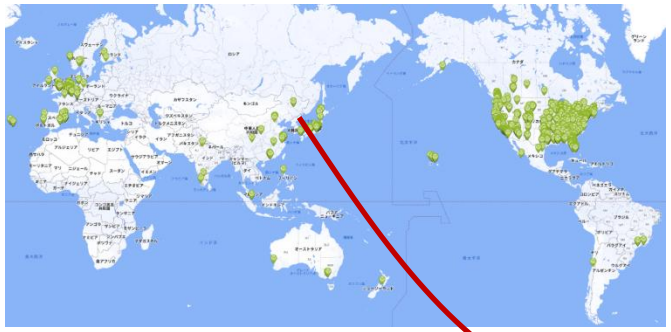
104 countries / territories

eduroam JP

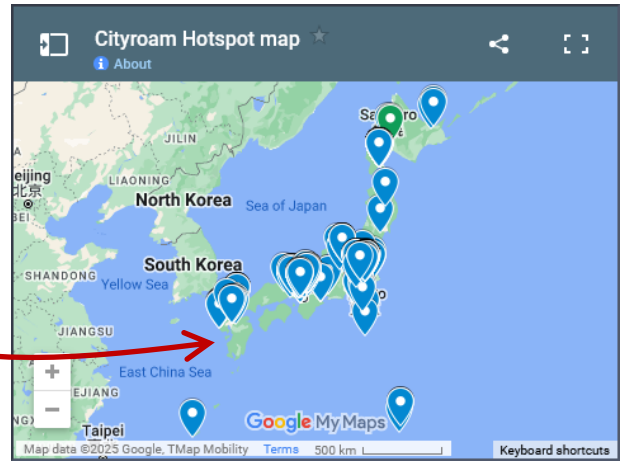


OPENROAMING™
WIRELESS BROADBAND ALLIANCE

for Everyone (2020-)



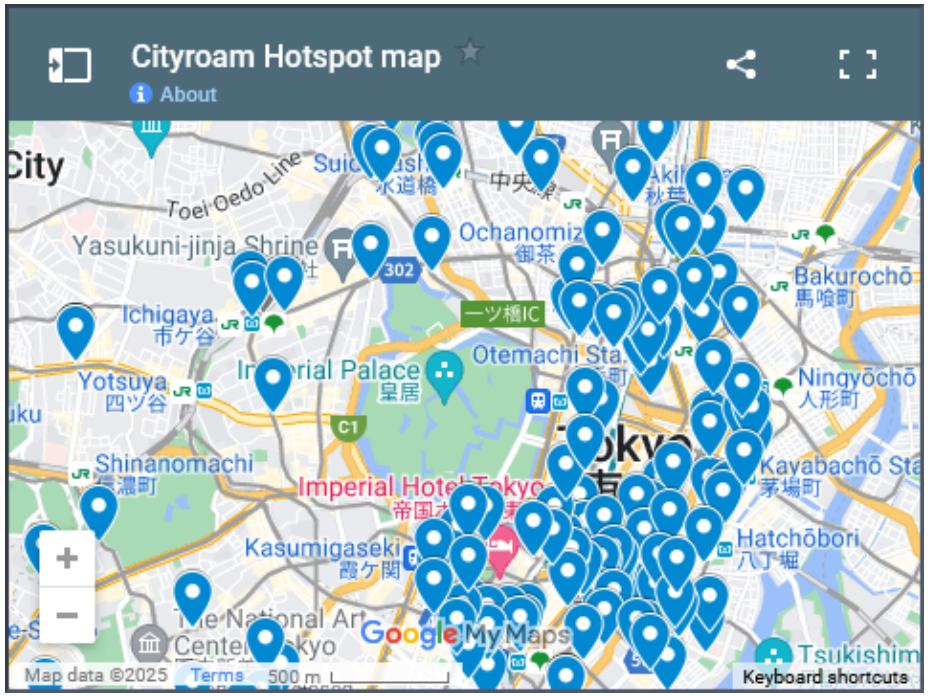
cityroam



1000+ spots (July 2025)
eduroam is combined.

TOKYO FREE Wi-Fi supports OpenRoaming

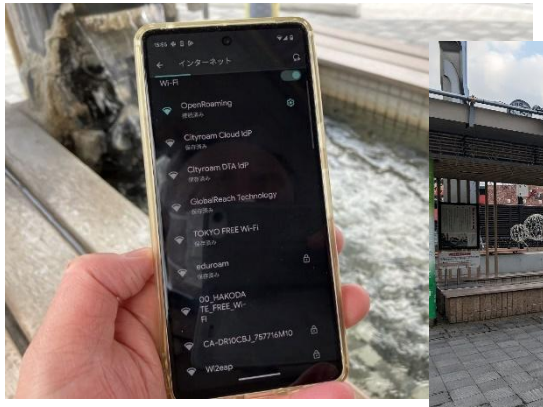
- Released on Mar. 31, 2023
- Tokyo Metropolitan Government + KDDI / Wire & Wireless (Wi2)
- Enhanced security, safety, and usability. ☺

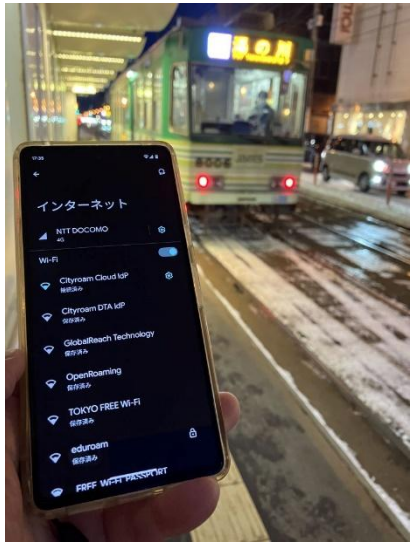


https://wi-fi.metro.tokyo.lg.jp/en/

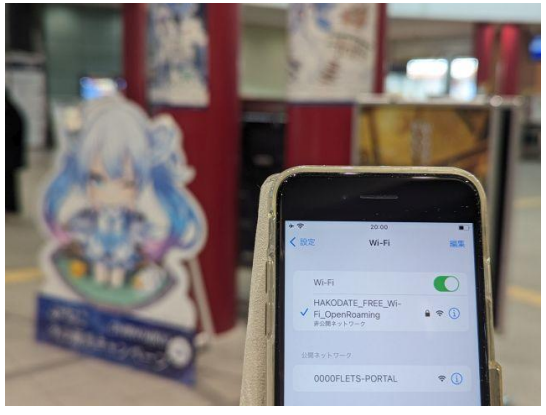
HAKODATE FREE Wi-Fi

- Nov. 30, 2023 –
- eduroam and OpenRoaming become available.





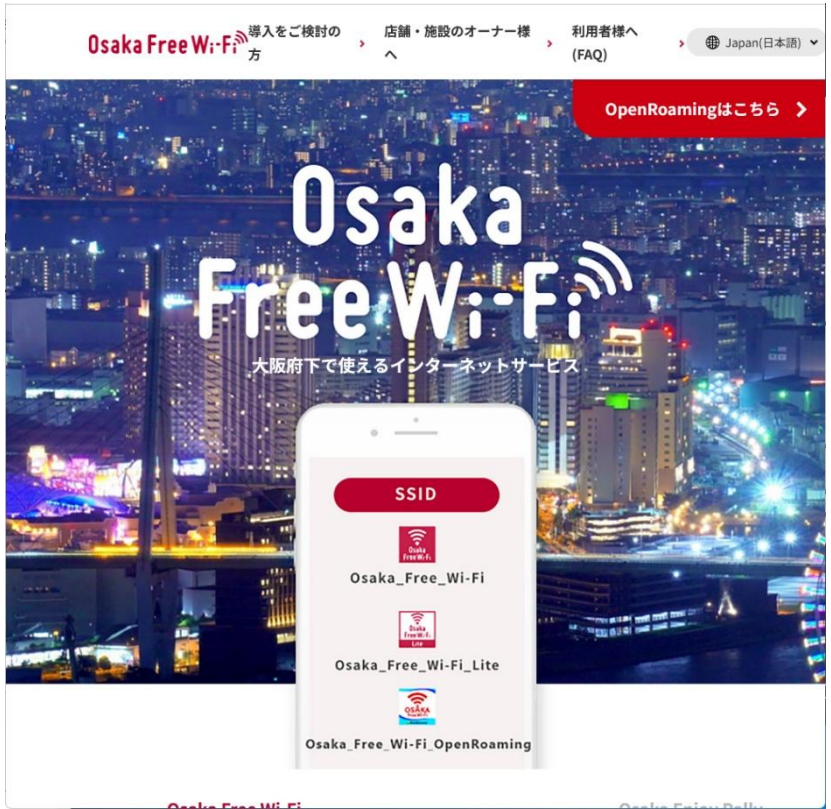
Enjoy eduroam / OpenRoaming
at the footbath (hot spa), airport, trams !



https://wi2.co.jp/release/press/2023/20231130-hakodate_openroaming.html

Osaka Free Wi-Fi

- Oct. 10, 2024 –
- Initial deployment focuses on Public Transport. (for EXPO 2025)

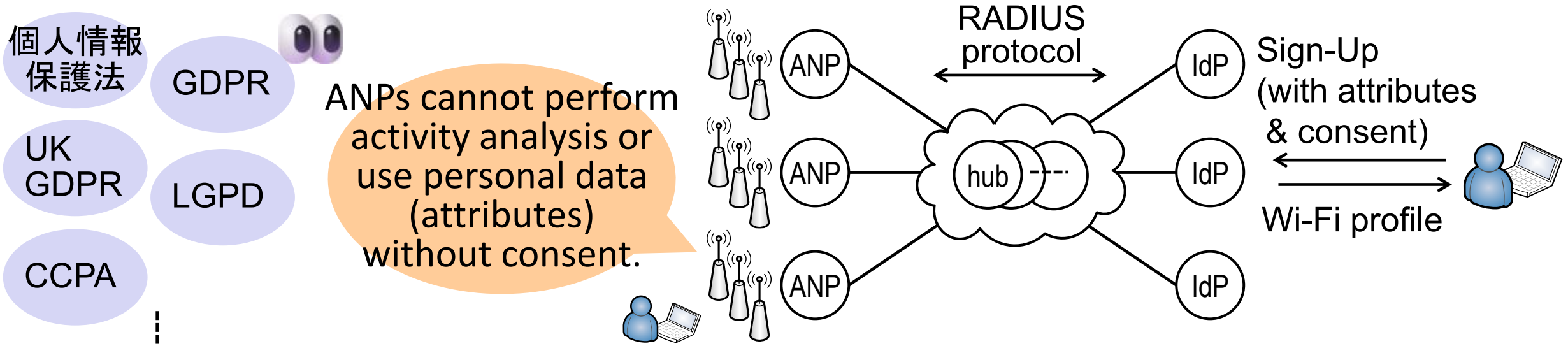


OSAKA Free Wi-Fi
Open Roaming

https://ofw-oer.com/

Challenges in user activity analysis and data usage

- IdP and ANP are separated.
- **ANPs cannot see “real user ID” or obtain user’s consent.**
  - Outer-Identity is anonymized, e.g. anonymous@example.com
    Inner-Identity is protected by **EAP tunnel** between User Device - IdP.
  - EAP-TLS (with TLS 1.3) hides the contents of Client Certificate.
  - Ephemeral MAC addresses, etc.



ANP: Access Network Provider
EAP: Extensible Authentication Protocol

Problems, and Research Objectives

- Lack of standard framework for attribute/consent sharing imposes **significant impact to the business model,** introducing a great hurdle in deploying Wi-Fi Roaming.
- Roaming systems suffer from a large number of **invalid authentication requests** from devices with expired or revoked credentials.

Objectives

- Explore some methods for sharing attributes/consent in an *offline manner*.
- Address the high load problem.
- Prepare for some prospective use cases, including *disruption-tolerant Wi-Fi roaming systems*.

Development of a user data sharing system

- Owners want to know / do …
  - Age group
  - Gender
  - Nationality
  - Language (browser setting)
  - Device/OS (for app development)
  - Wi-Fi usage location and staying time
  - Travel routes (e.g. shop-hopping in a mall, tourist sites), etc.

- Especially, municipalities want to know / do …
  - Travel routes
  - Analysis of tourist sites
  - Analysis for disaster response / mitigation, and urban design

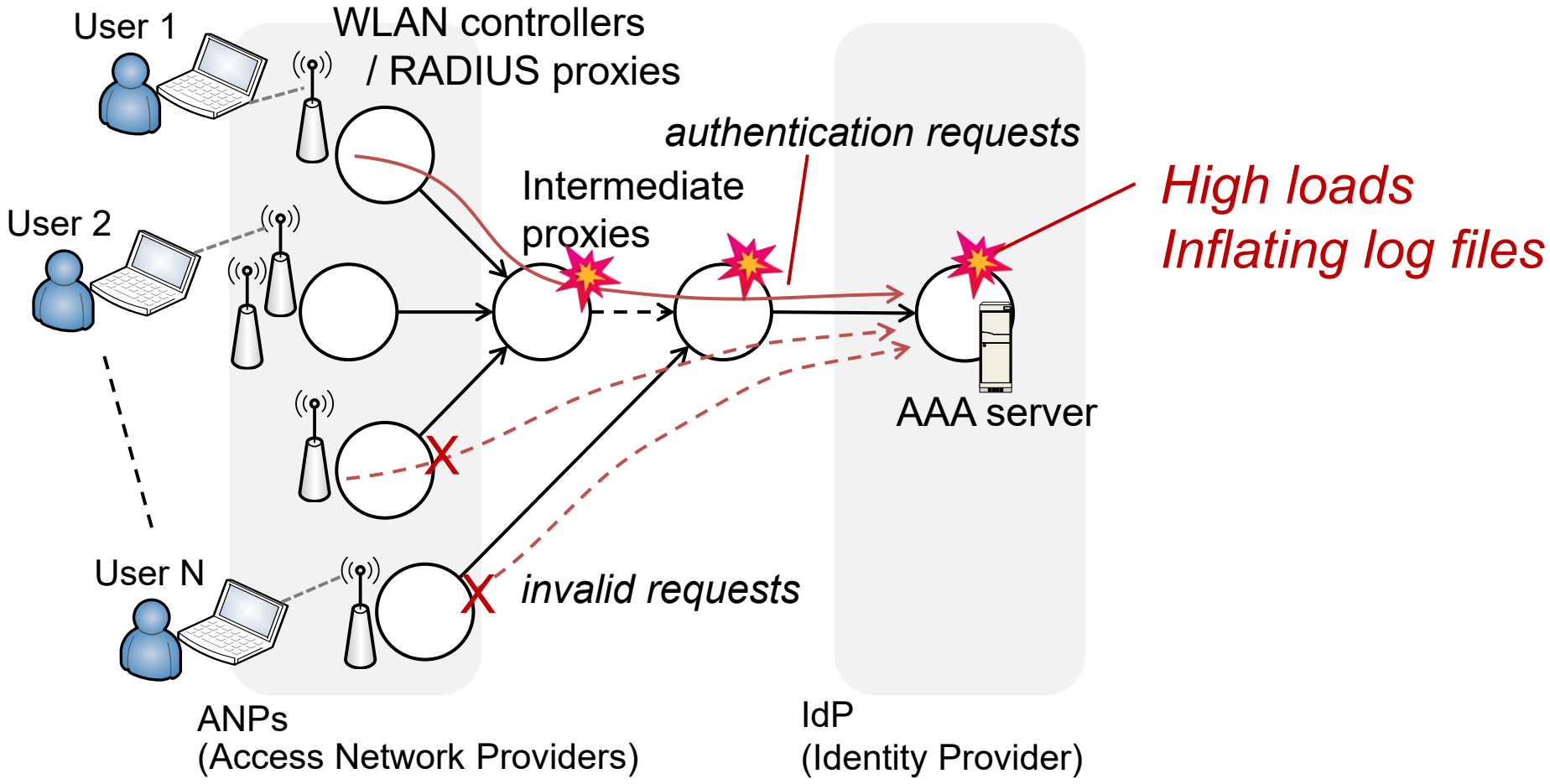
Three methods

1. Embed Valid Until date in the RADIUS User-Name.
   - Suppress invalid authentication requests.
   - Can be forged, but with no significant impact.

2. Embed simple attributes in the User-Name securely.
   - Suitable for public attribute sharing.
   - Tamper-resistant.

3. Per-group attribute sharing using Local Authentication and ECDH
   - Generalized, group-based attribute sharing.
   - Tamper-resistant.
   - Realize User Activity Analysis and Personal Data Usage even in roaming systems.

1. Reducing invalid requests caused by expired/revoked credentials



1. Reducing invalid requests caused by expired/revoked credentials

Solution

Embed Valid Until data in the User-Name so that ANPs can see it and stop invalid requests.

anonymous@**vu250331**.example.com

(realm part)

Why in the realm part? – ANPs can see only Outer-Identity.
User ID is often anonymized.

User can modify it ! – AAA server knows real date. ☺

In 2023, our multi-tenant eduroam IdP service saw:

9.6% expired credentials, (= max reduction rate)

20.4% AuthN failure log lines

2. Tamper-resistant attribute sharing method with *Local Authentication*

(H. Goto, JIP 2024)

Solution

Embedding attributes and digital signature.

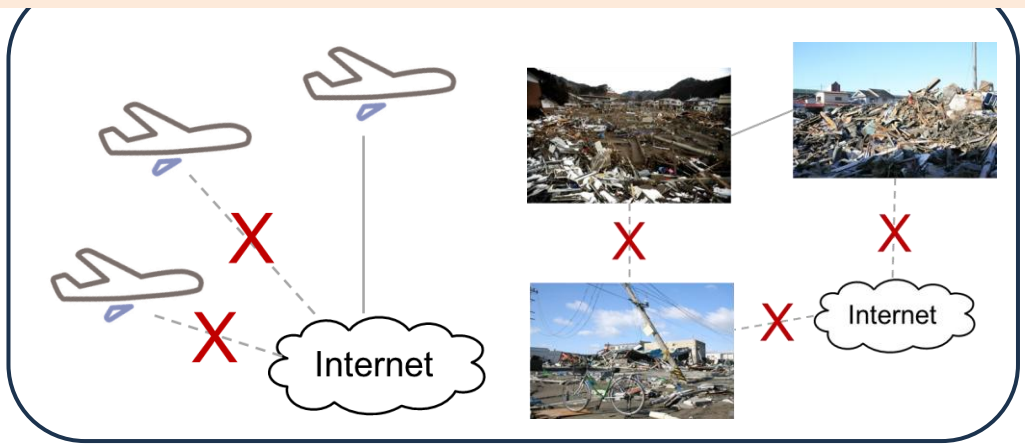
CYEPBcv7T|MCUCEQC3SwoCbmNfPno3KRv
ZP7qLAhBg+cHjunGEo6CwKPzHeNz7@**xattrjez**
tqpof52n2xxm7vphkeocp5aqbil43.example.com

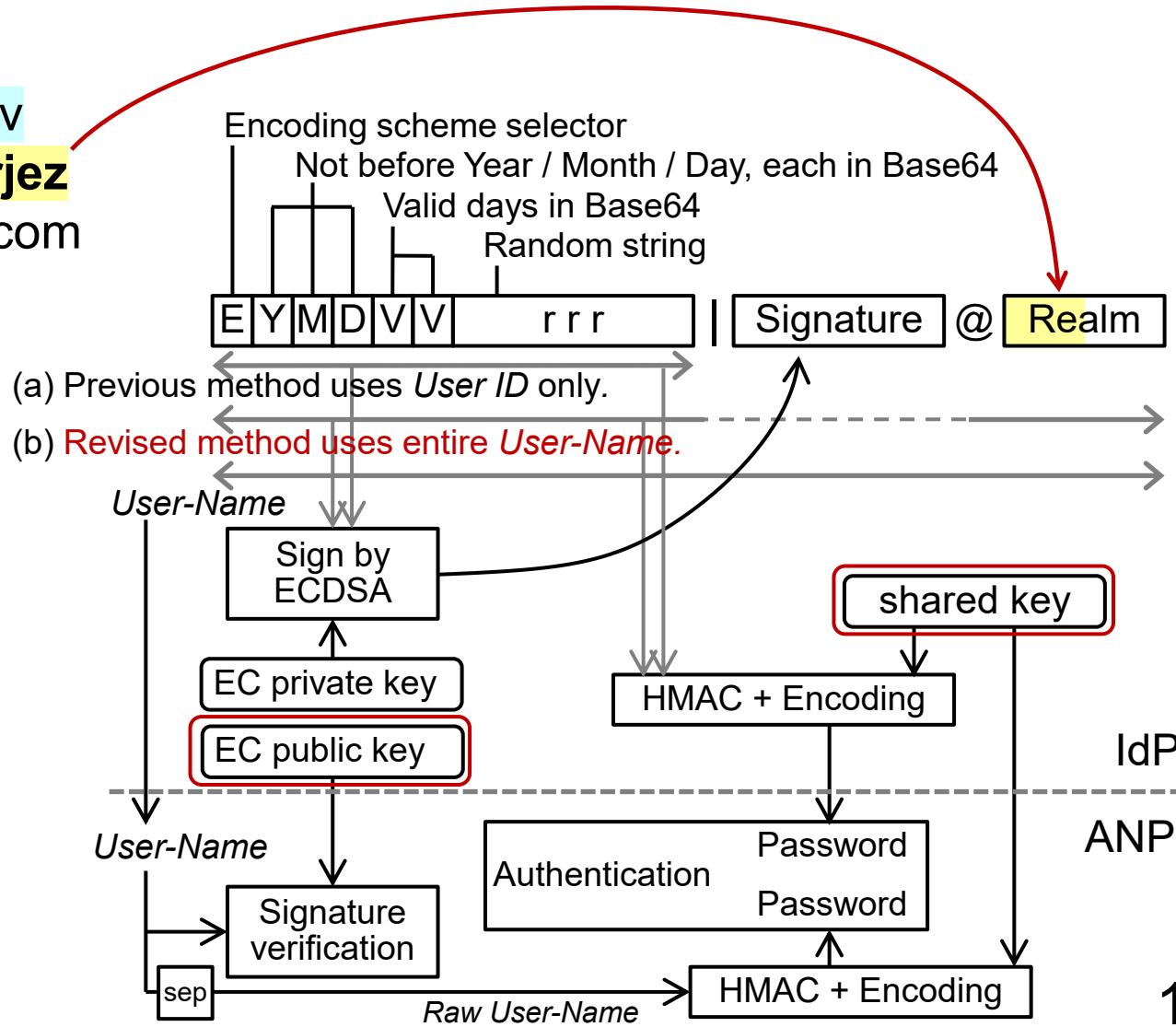
Use regex for realm-based routing.

realm "~^(.+\.)?example\.com$“ { … }

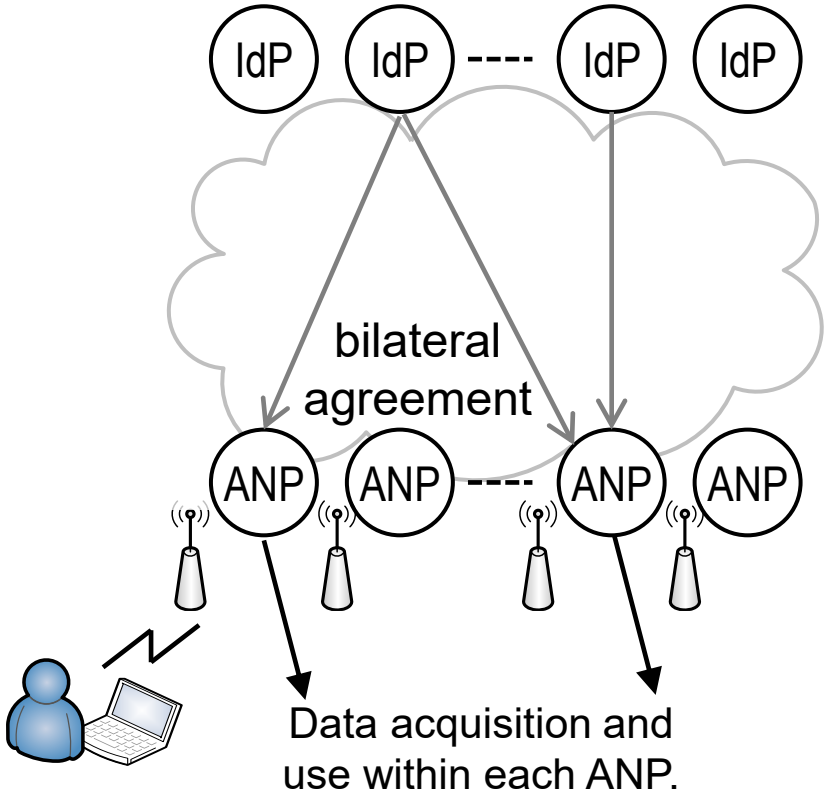
Prospective use cases:

In-Flight Wi-Fi, and Public Wi-Fi in disaster-affected areas

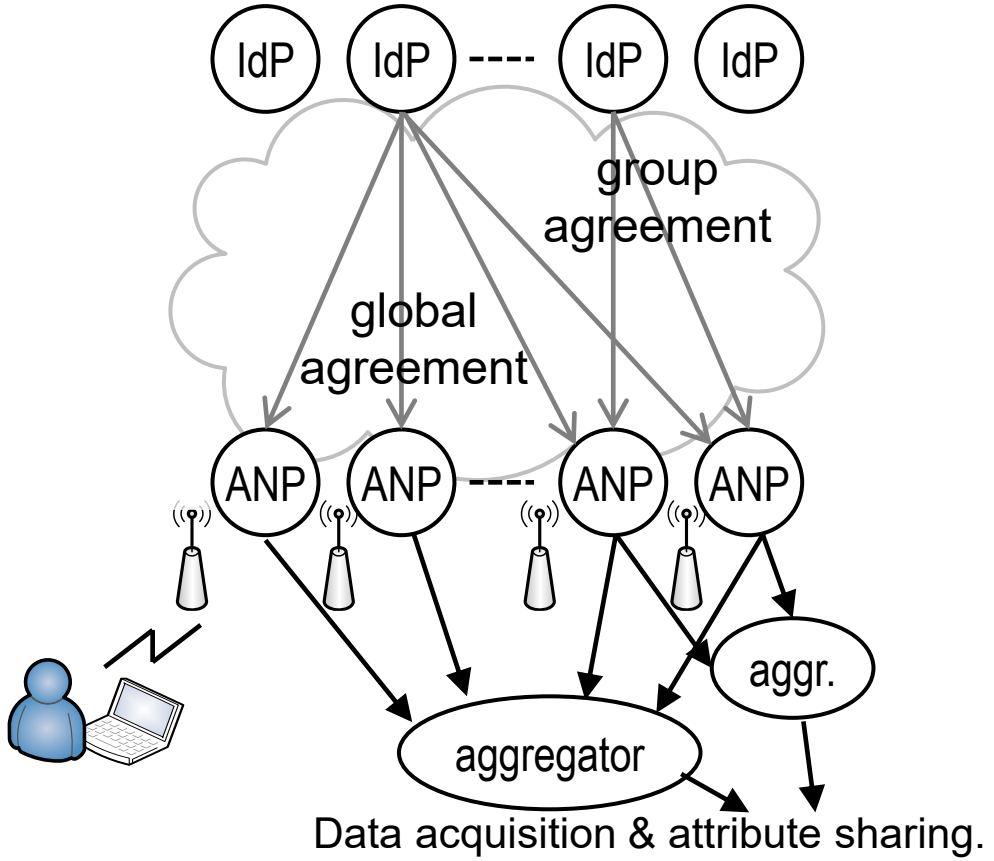




3. Per-group attribute sharing using Local Authentication and ECDH



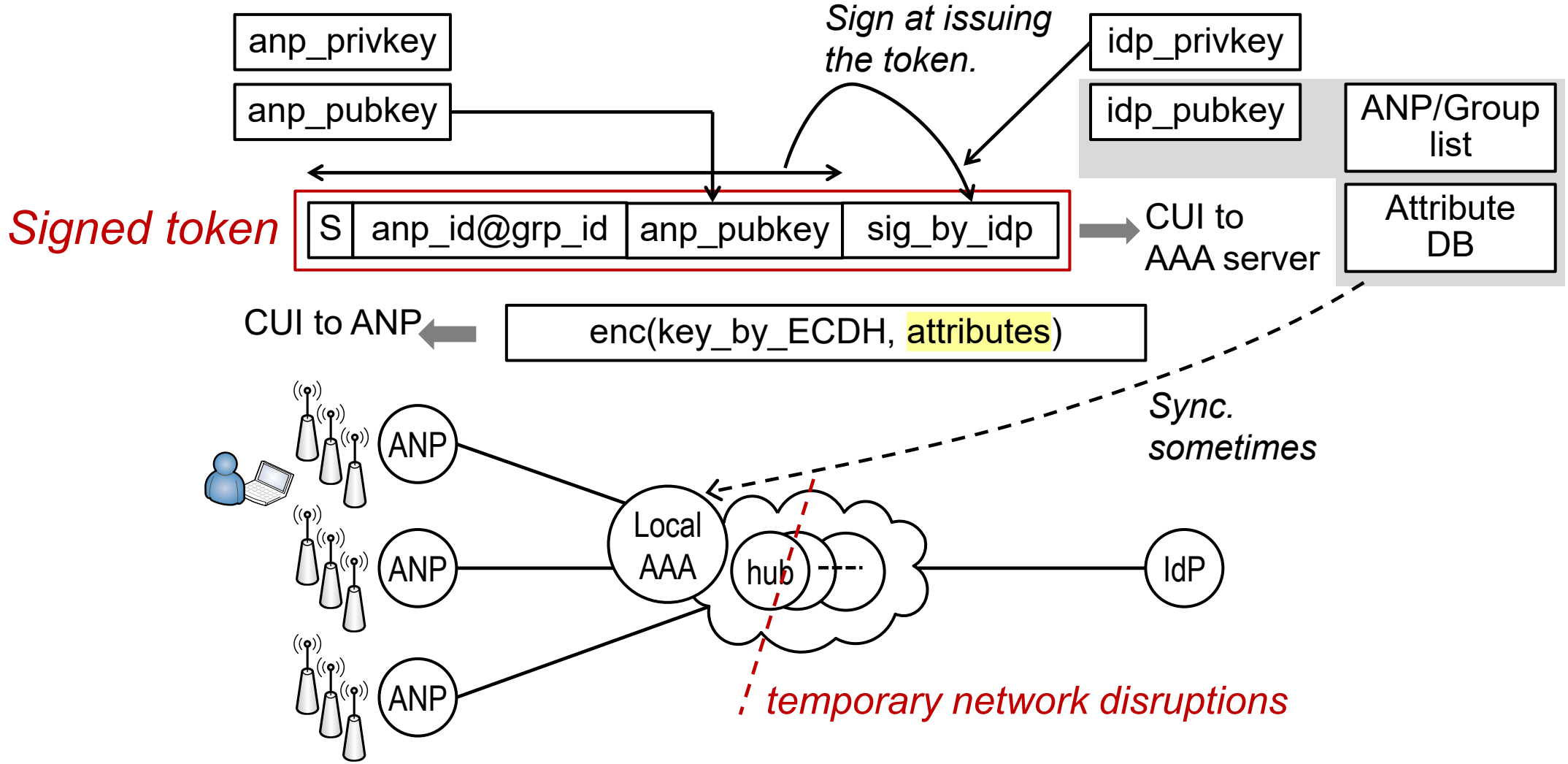
(a) Conventional roaming system based on bilateral agreements.



(b) Roaming system with global / per-group attribute sharing.

3. Per-group attribute sharing using Local Authentication and ECDH

- Use RADIUS protocol to deliver attributes.
- Support occasional changes of user attributes.

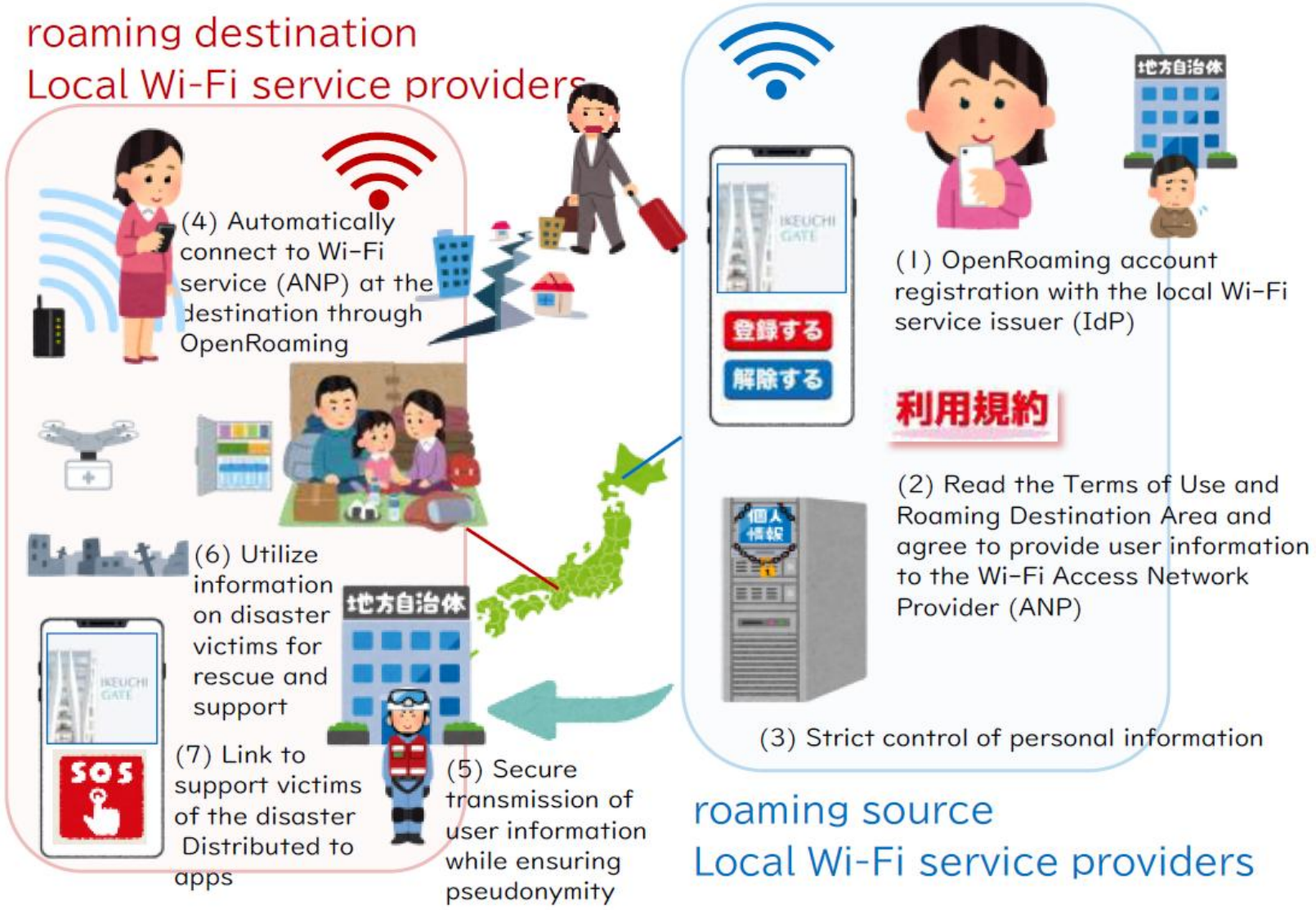


Use case 1: Regional tourism apps

Y. Okabe et al.,
IPSJ CDS43, 2025

Commissioned research 23610 by National Institute of Information and Communications Technology (NICT), Japan (2024-2025)

Use case 2: User search and support under natural disasters



Commissioned research 23610 by National Institute of Information and Communications Technology (NICT), Japan (2024-2025)

Conclusions

Developed three methods for attribute sharing.

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   - Reduce invalid authentication requests.
2. Embed simple attributes in the User-Name securely.
3. Per-group attribute sharing using Local Authentication and ECDH
   - Generalized, group-based attribute sharing.
   - Tamper-resistant.
   - Realize User Activity Analysis and Personal Data Usage.

Future work

- Develop attribute/location-based services for roaming systems.
- Business model development and analysis.