

Building a national Secure Wi-Fi infrastructure with international roaming

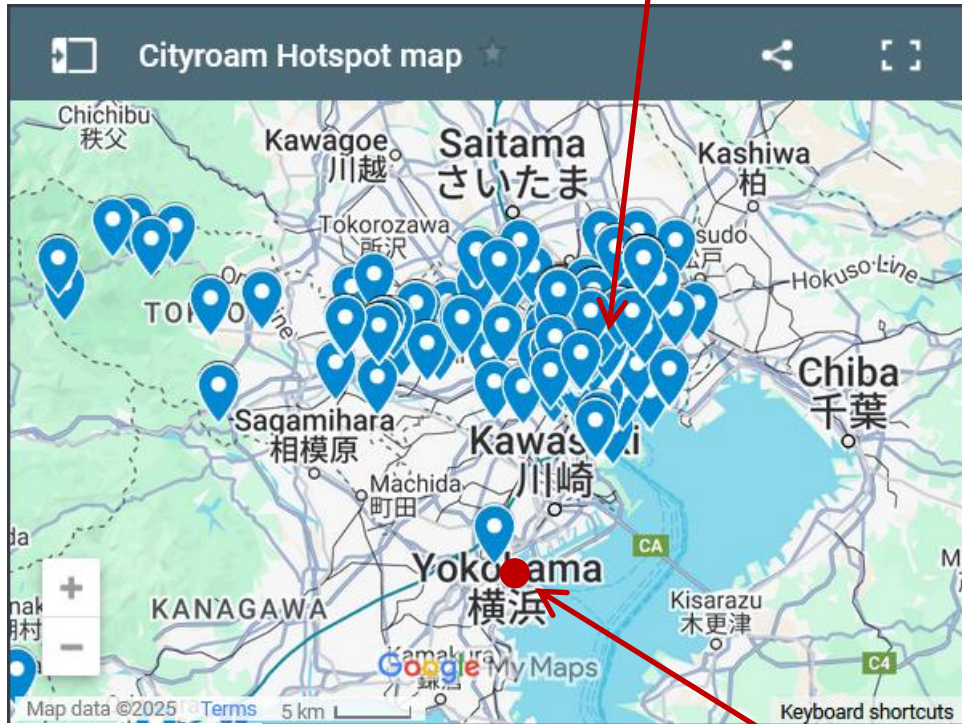
– Supporting the society and education in the digital era –

Hideaki Goto Tohoku University / NII, Japan



OpenRoaming is available here!

Tokyo



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

Google, Apple, or LINE account is required for Sign-Up.



cityroam

for more locations, etc.

APAN59 venue

Nationwide Cityroam deployment in Japan

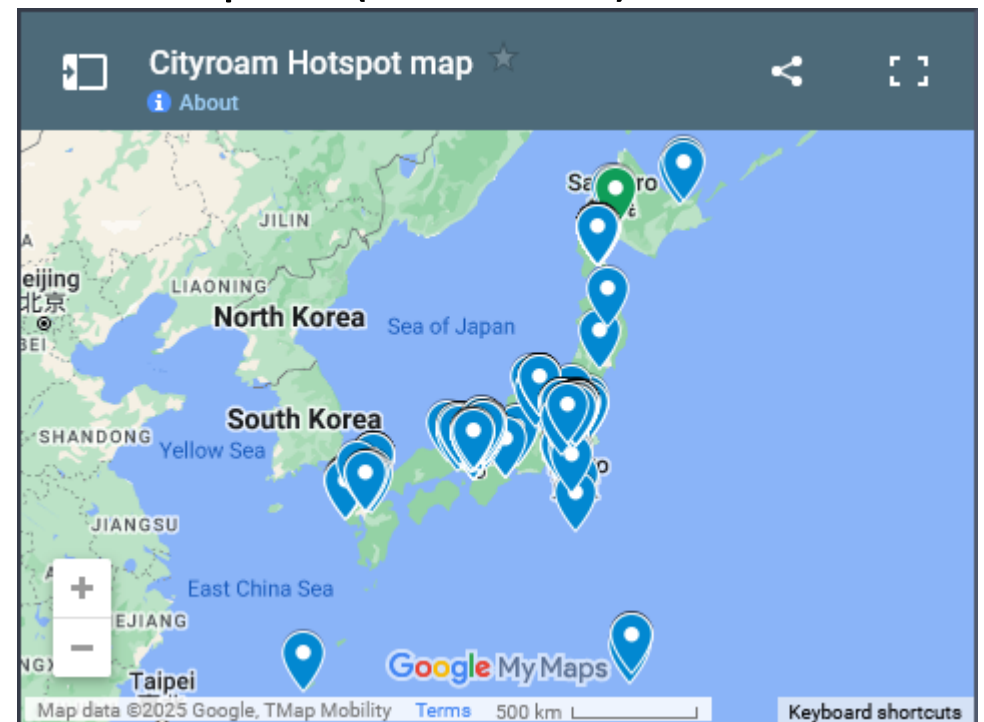
Your countries
can have a
similar one !

- Cityroam, a federation providing secure roaming system for Public Wi-Fi since 2018.
- All sites provide both **eduroam** and **OpenRoaming** (2020-).
- **Unique sites** across the nation.



cityroam

1000+ spots (Jan. 2025)



Why Public Wi-Fi?

Pros

- Higher bandwidth than cellular networks
- Autonomy
- Easier deployment with freedom
- Less expensive deployment and operation
- Less technical knowledge



Cellular network isn't enough ?

Cons

-> can be overcome

- Low (or no) security in the legacy Free Wi-Fi systems
 - Many people say “security is a concern”.
They are still using it or won't use it at all !
- Cumbersome registrations here and there
- Unclear privacy protection measures

Public Wi-Fi as an infrastructure

■ WiFi4EU's case

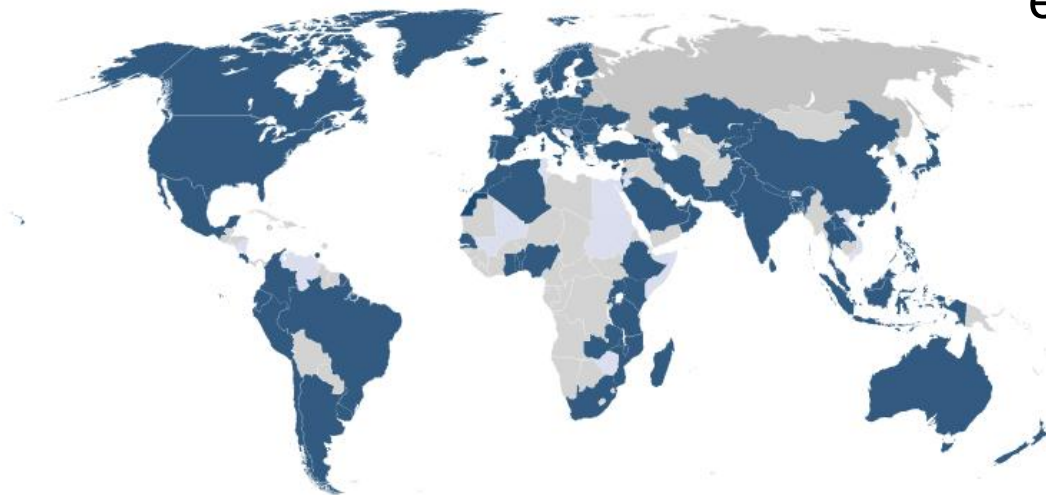
- Project for EU-wide Free Wi-Fi deployment
- Public Wi-Fi is a society infrastructure like water and electricity.
- Provide network access means to everyone including those who cannot have a DSL at home.
- Access to digital government services is crucial.

“Everyone benefiting from connectivity means that it should not matter where you live or how much you earn. So we propose today to equip every European village and every city with free wireless internet access around the main centres of public life by 2020.

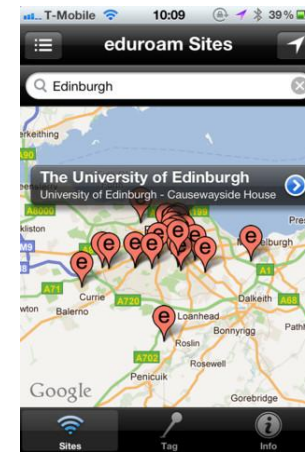
Jean-Claude Juncker - State of the Union speech, September 2016”

eduroam (RFC 7593)

- Secure Wi-Fi Roaming system for Research & Education
 - Started as a pilot at TERENA (now GÉANT).
 - 104 countries/territories worldwide (as of 2025)
 - De facto standard of campus Wi-Fi in the world.
 - Mutual benefit system.
 - High security and usability based on 802.1X.

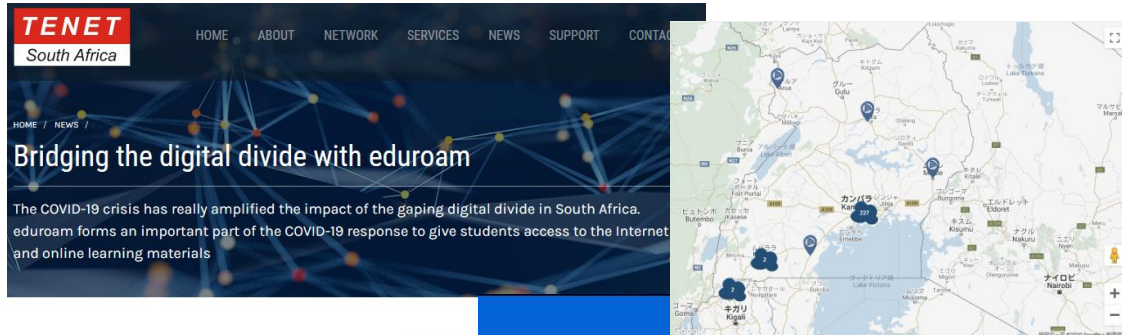


eduroam Companion (Android, iOS)



Off-campus eduroam as a digital infrastructure

South Africa:
eduroam at most universities, addressing digital divides and COVID-19 (July 2020)



The banner features the TENET South Africa logo and navigation menu. The main headline reads "Bridging the digital divide with eduroam". Below it, a paragraph states: "The COVID-19 crisis has really amplified the impact of the gaping digital divide in South Africa. eduroam forms an important part of the COVID-19 response to give students access to the Internet and online learning materials". To the right is a map of South Africa with several blue location pins indicating eduroam access points.

Today a University of Cape Town student living in Khayelitsha can access eduroam, the high-speed internet offered by nearly all South African universities and an additional 105 countries around the world, at their local library. A University of Witwatersrand (Wits) student living in Sebokeng needs only to travel 30 minutes to North-West University's Vaal Triangle Campus to download their course content and videos quickly and for free on the eduroam network, while a University of South Africa (UNISA) student anywhere can check the [eduroam interactive map](#) to see where their closest internet access point is.



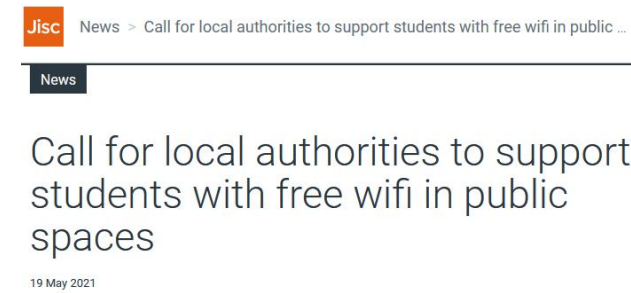
The graphic features the eduroam logo at the top. Below it, the text asks: "Are you a Student, Researcher or University Staff?". It then states: "Covid-19 has pushed us off campus, and reliable off-campus connectivity is a problem." and "eduroam has now gone beyond your campus borders." Further text says: "Look out for the eduroam Wi-Fi network in your neighborhood." and "Free, simple, seamless connection at your convenience." At the bottom, there are social media icons, the website www.renu.ac.ug, the phrase "SECURE & TRUSTED", and the RENU logo.

RENU in Uganda:
Town-wide eduroam
to help students
learning under COVID-19 (Oct. 2020)



The snippet shows the top of a news article from University Times, dated Jan 5, 2021. The headline is "Government to Extend WiFi Initiative for Students to 90 New Locations". The sub-headline reads: "Difficulty accessing the internet in rural communities has become a major talking point in higher education circles since the outbreak of the pandemic." The author is Cormac Watson, Editor. A photo of Simon Harris is visible. The text continues: "The government will extend internet access for students to 90 new locations across the country in order to create 'extended virtual campuses', Higher Education Minister Simon Harris announced today. HEAnet will lead the initiative, rolling out **eduroam** - a WiFi connection that students can automatically connect to - to locations accessible to students, such as libraries, museums, public offices, coffee shops and shopping centres. **eduroam** is already available to students in a number of locations, including libraries in Longford and Galway, the Convention Centre and Custom House Quay in Dublin."

“Extended virtual campuses”
in Ireland (Jan. 2021)
<http://www.universitytimes.ie/2021/01/heanet-to-extend-wifi-initiative-for-students-to-90-new-locations/>



The snippet shows a news article from Jisc, dated 19 May 2021. The headline is "Call for local authorities to support students with free wifi in public spaces". The text begins: "Building on efforts to tackle digital poverty, Jisc has written to the Local Government Association, urging authorities to provide free internet access to students in public spaces via our eduroam connectivity service."

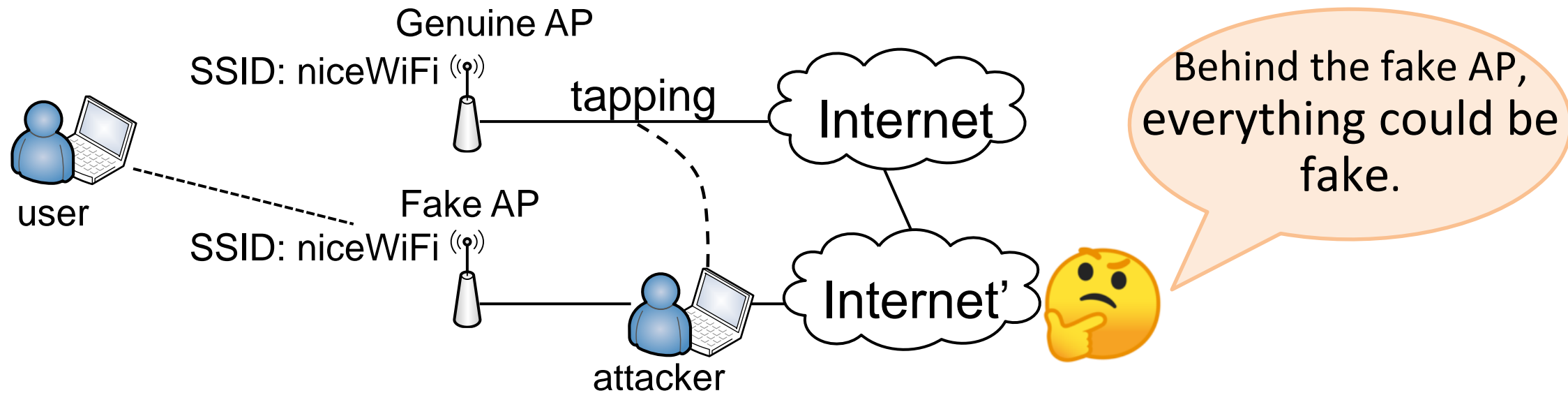
Building on efforts to tackle digital poverty, Jisc has written to the Local Government Association, urging authorities to provide free internet access to students in public spaces via our eduroam connectivity service.



Jisc, UK (May, 2021)

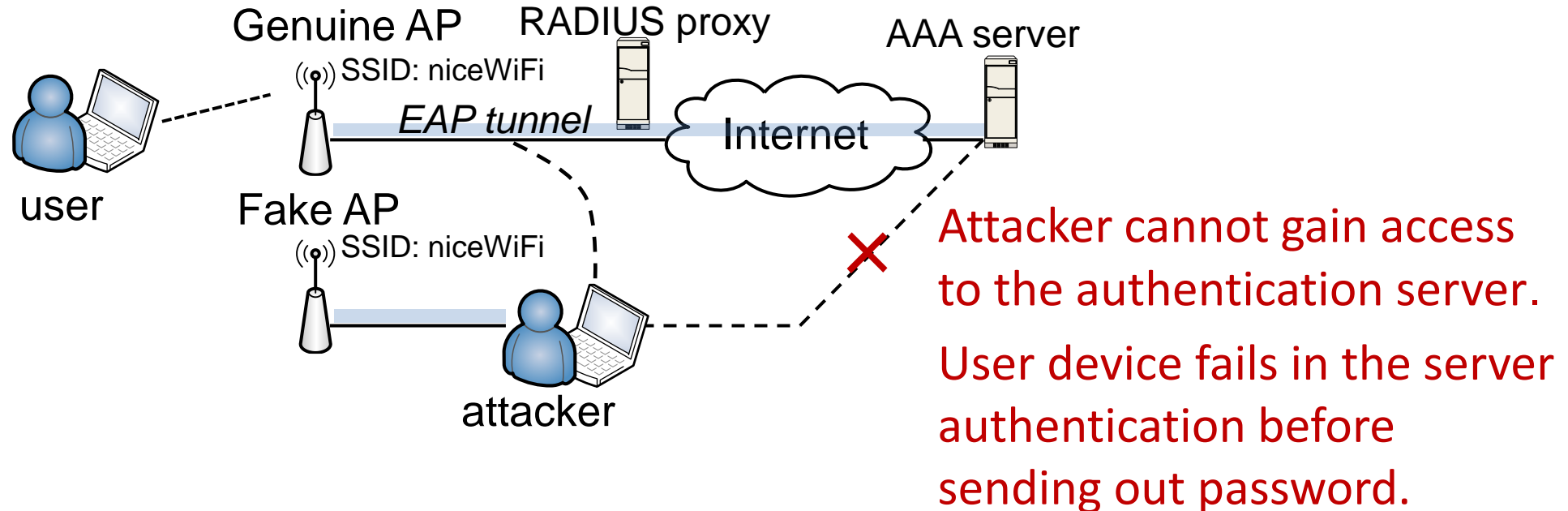
Evil Twin Access Points

- If *open Wi-Fi* is used, there's no security or privacy. Anyone can plant an Evil Twin AP.
- If many people are using *WPA Personal*, sharing a *Pre-Shared Key* (PSK), the network is also unsecure.
- If you have joined a fake network, many attacks become possible. E.g., MITM, eavesdropping, malware injection, and active attacks.



Secure Public Wi-Fi Using WPA2/WPA3 Enterprise

- Users should check whether the AP is a genuine one provided by an authorized operator.
Server authentication in 802.1X makes it possible.
- Password protection as well as privacy protection is needed.
EAP (Extensible Authentication Protocol) can provide protection.



Wi-Fi Security is not only for end-users...

- Security for Wi-Fi operators:
 - Make clear the responsible bodies.
 - Keep user traceability in case of network abuse or crime.
User Verification is important.
- Security for the society:
 - Suppress crimes such as fraud.
 - Suppress organized crimes and terrorisms.
 - Disaster prevention and mitigation utilizing user activity analysis.
 - Smart City design through data analysis.
 - Securing people's communication means under disasters.



WBA OpenRoaming




- **Seamless connection experience for everyone.**
eduroam-like, but not limited to Research&Education community.
 - eduroam since 2003, now 100+ countries/territories.
- **Advanced and multipurpose** than eduroam (RFC 7593).
- Based on Passpoint and WRIX framework.
- PKI and RadSec + Dynamic Peer Discovery
 - Similar to eduroam, but in larger scale.
- Two policies using different RCOIs
 - Settled: Accounting and intermediary are required.
 - **Settlement-free: No roaming fee. Much easier adoption.**

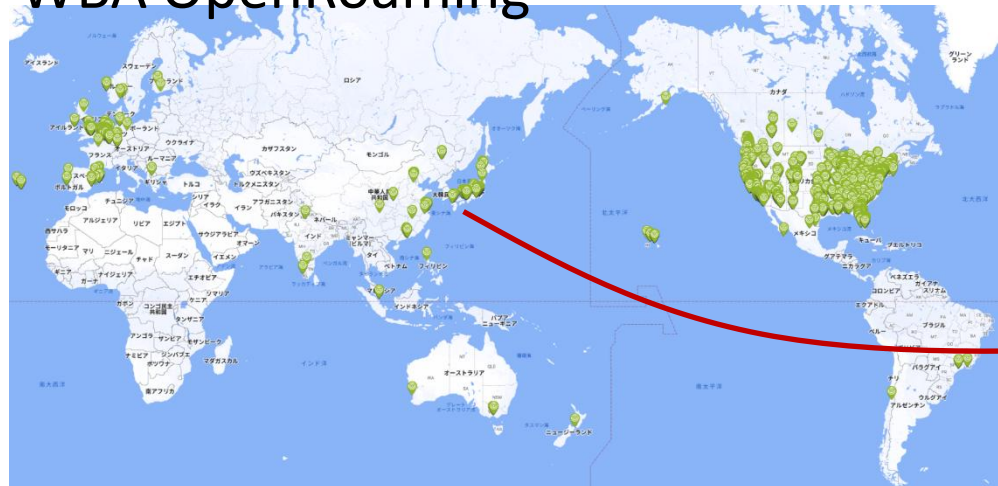
Fit with our purposes.



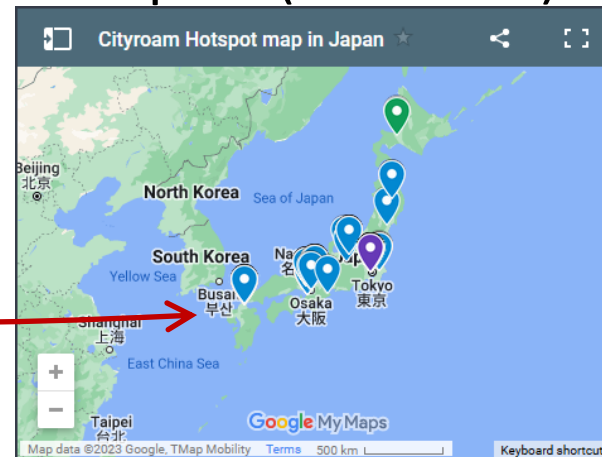
Cityroam's rapid growth – why?

- Organized a Roaming Federation
 - **Community supports** (seminars, tech tests & discussions, etc.)
 - -> **Wireless Identity Federation Association** (est. Apr. 2024)
- **Affordable roaming platform with Simplified inter-connections (central hub).**
 - IdP: eduroam, Cityroam Cloud IdP, operators in Japan, telcos/ISPs and cities overseas via 
- eduroam/OpenRoaming combined architecture
- **Involvement of Municipal Wi-Fi** (multi-vendor, multi-operator scheme)

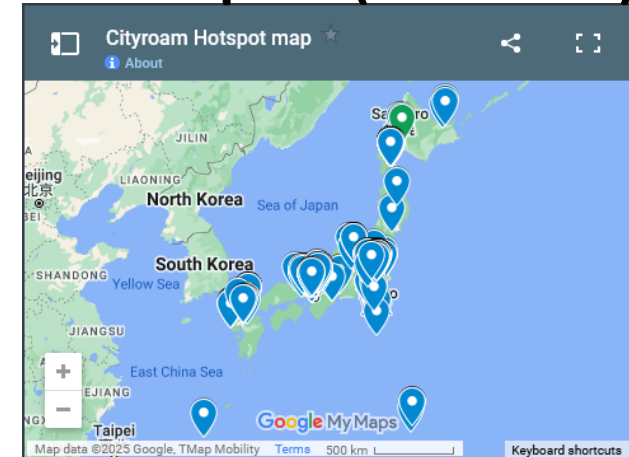
WBA OpenRoaming



90+ spots (Jan. 2023)



1000+ spots (Jan. 2025)



Cityroam sites – early adopters of OpenRoaming



Co-working space in Morioka
(OpenRoaming was added
in 2020)



Conference Center in Nagano
(May 2021)



Hot Spring facility in Nagano
(May 2021)



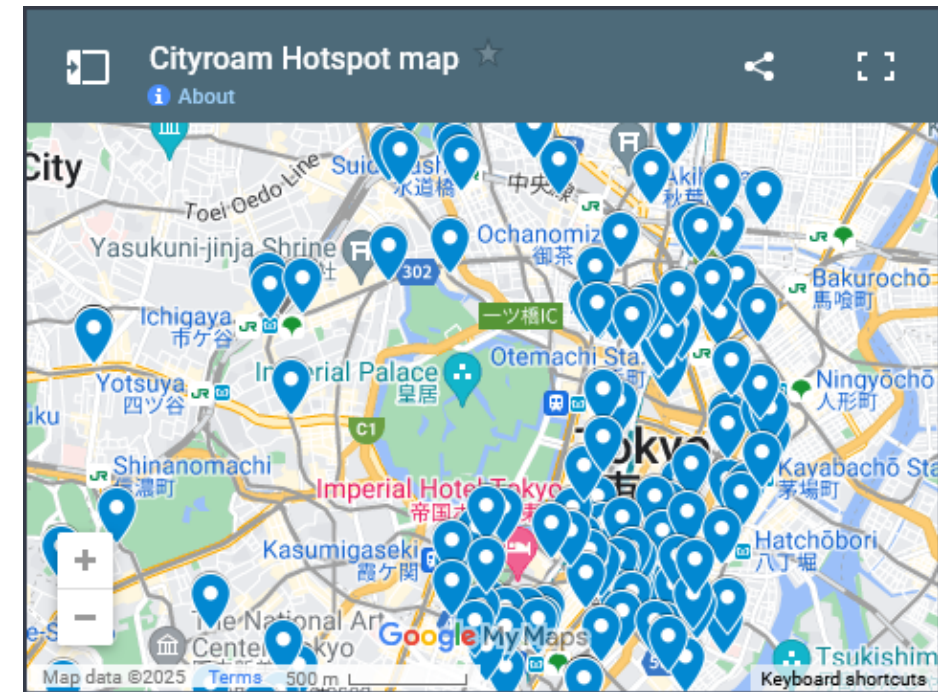
Resort Hotel & Complex in Ise
(Feb. 2022)



Vending machines in
Kyoto City Parks
(May 2020)

TOKYO FREE Wi-Fi supports OpenRoaming

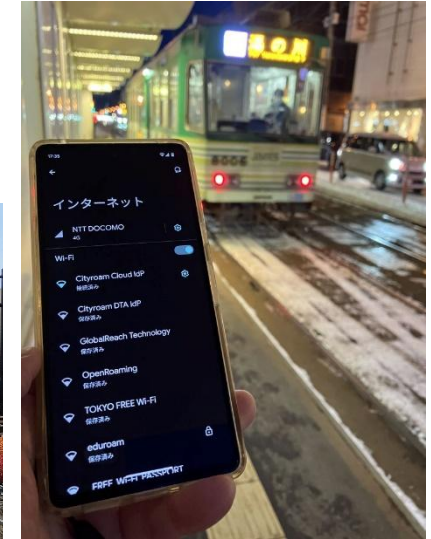
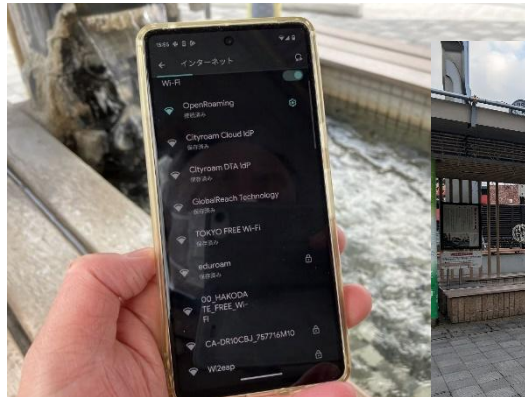
- Released on Mar. 31, 2023
- Tokyo Metropolitan Government + KDDI / Wire & Wireless (Wi2)
- Enhanced security, safety, and usability. 😊



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

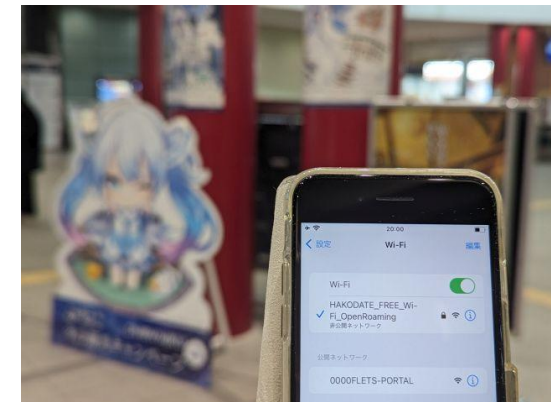
HAKODATE FREE Wi-Fi

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



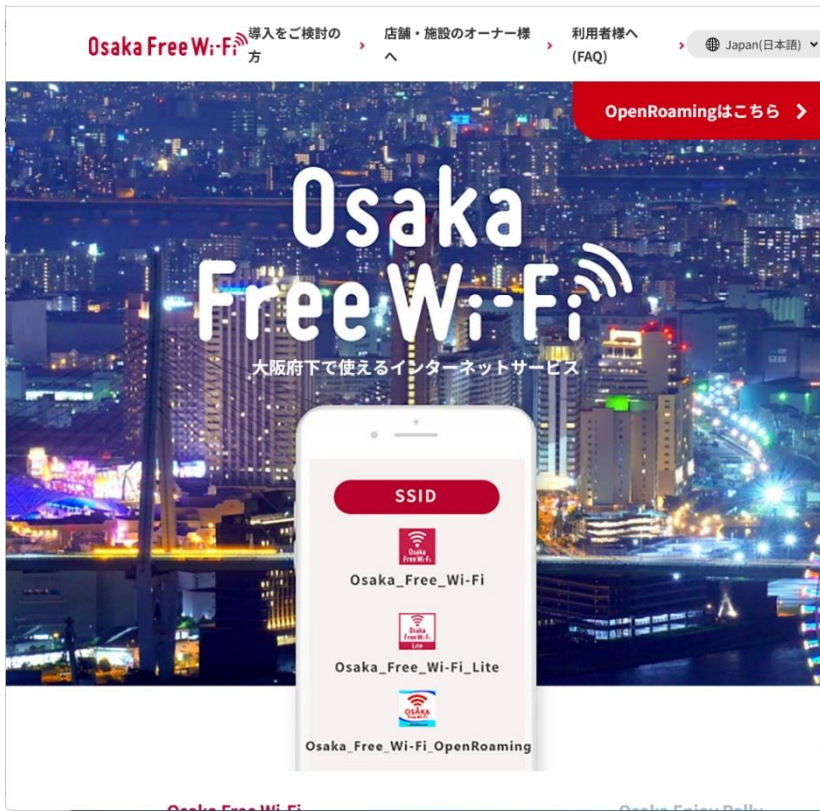
Enjoy eduroam / OpenRoaming at the footbath (hot spa), airport, trams !

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)



<https://ofw-oer.com/>

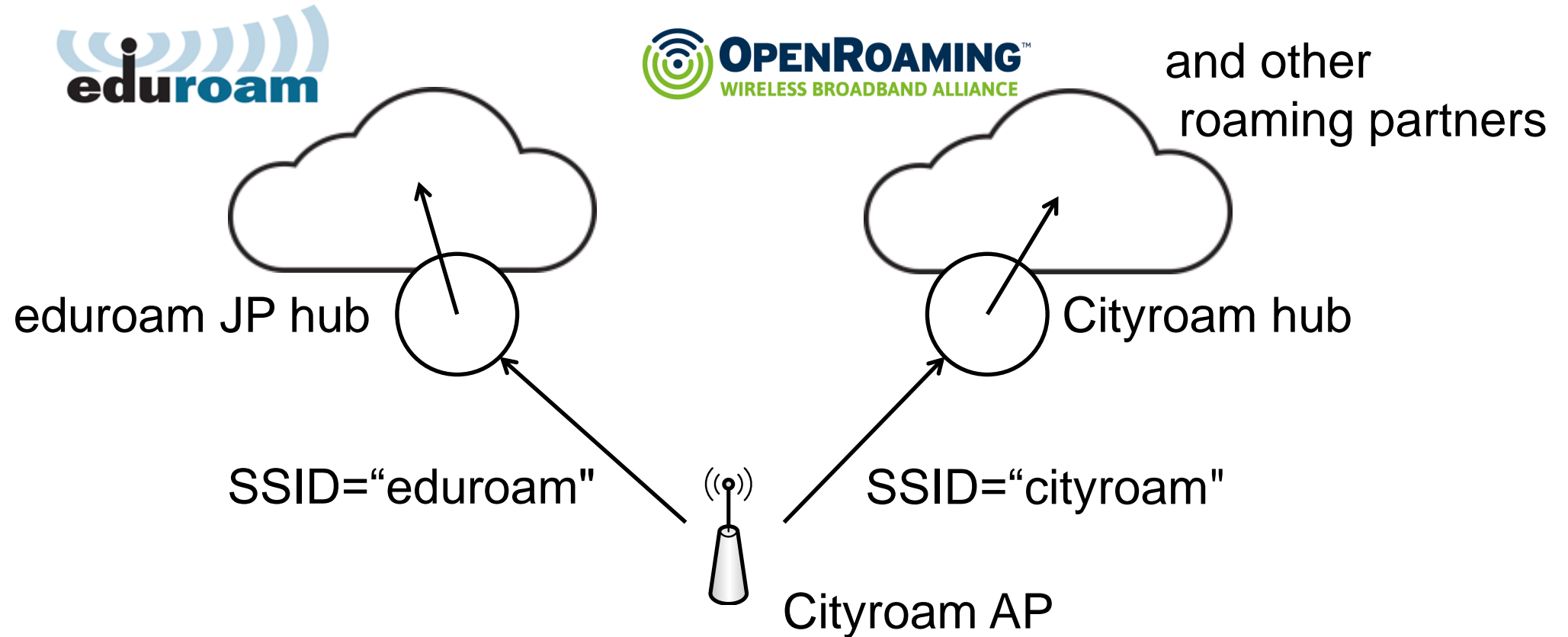


Why eduroam/OpenRoaming combination?

- eduroam has a matured **autonomy**.
 - Virtually monolithic.
If you see “eduroam” SSID, **the service is always there.**
 - Single basic policy + minor variants.
(won't bother users so much)
 - eduroam can be “**a group of reliable IdPs**”
that provides good credentials with strict user verification,
probably accompanied with enlightenment.
- Many students and staff are carrying devices already configured with eduroam.

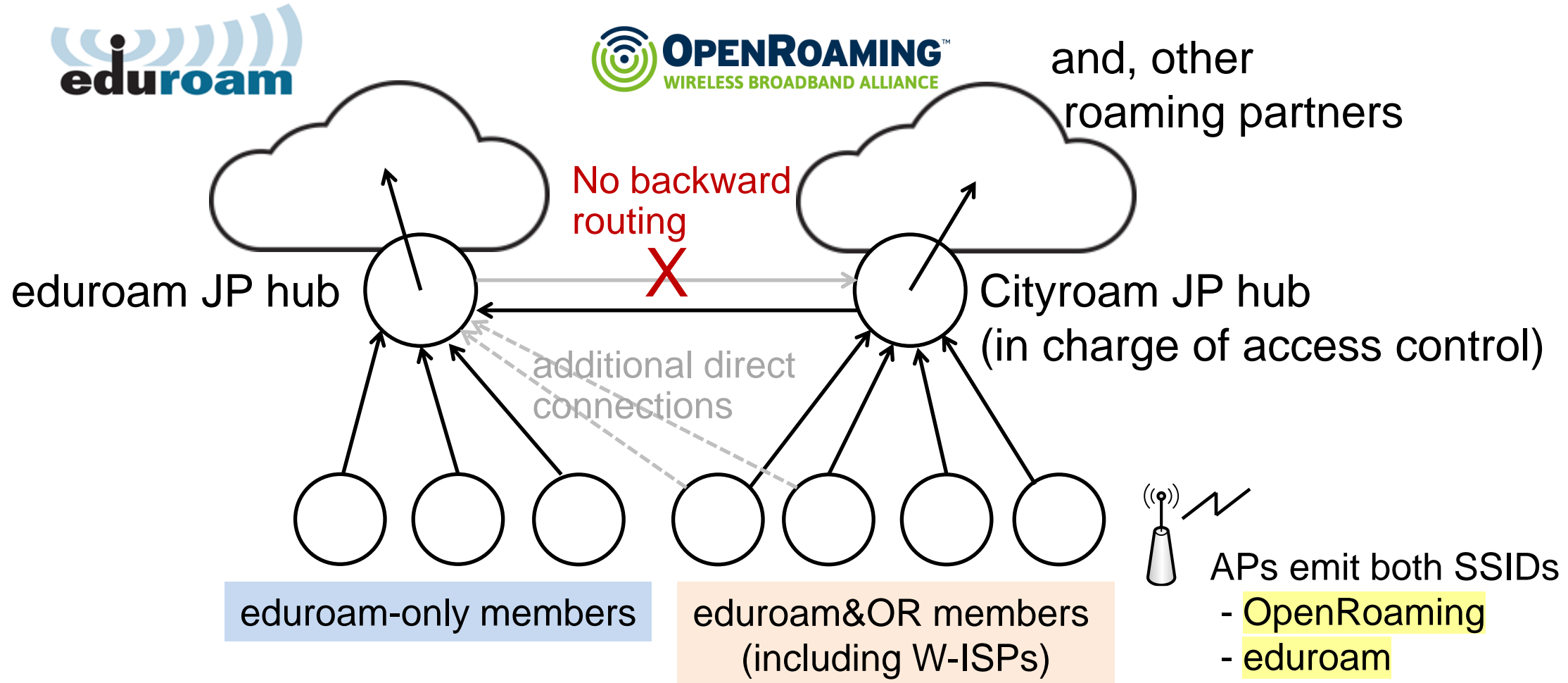
Great
advantage

eduroam traffic separation – basic (but complex) implementation



- Require multiple RADIUS connections
- Complex AP configuration

eduroam/OpenRoaming combined architecture



Forward to eduroam if ("`%{Called-Station-Id}`" =~ /:eduroam/)
(e.g. Called-Station-Id = de-ad-be-ef-01-23:eduroam)

Access analysis in the eduroam/OpenRoaming combined deployment

It is quite important to lower onboarding hurdles.

- **Municipal Wi-Fi profiles have become popular.** (>50%)
- SIM-based authentication is second popular.
 - User authentication is quite stable, with few errors.
- **eduroam accesses account for 10%.** (as of 2024)

Embedded profiles work well!

Summary

- eduroam / OpenRoaming combined deployment is quite useful for the societies in the digital era, supporting education, lifelong learning, tourism, and economy.
- Many municipalities in Japan (Kyoto, Tokyo, Hakodate, Kobe, Himeji, Osaka, etc.) have already deployed Cityroam.
- Cityroam architecture is open. You can do the same. 👍



On-going work

- **User activity analysis, data acquisition and sharing, under users' consent.**
- eduroam for K-12, IoT, and some other applications.



Supplementary slides

Development of a user data sharing system

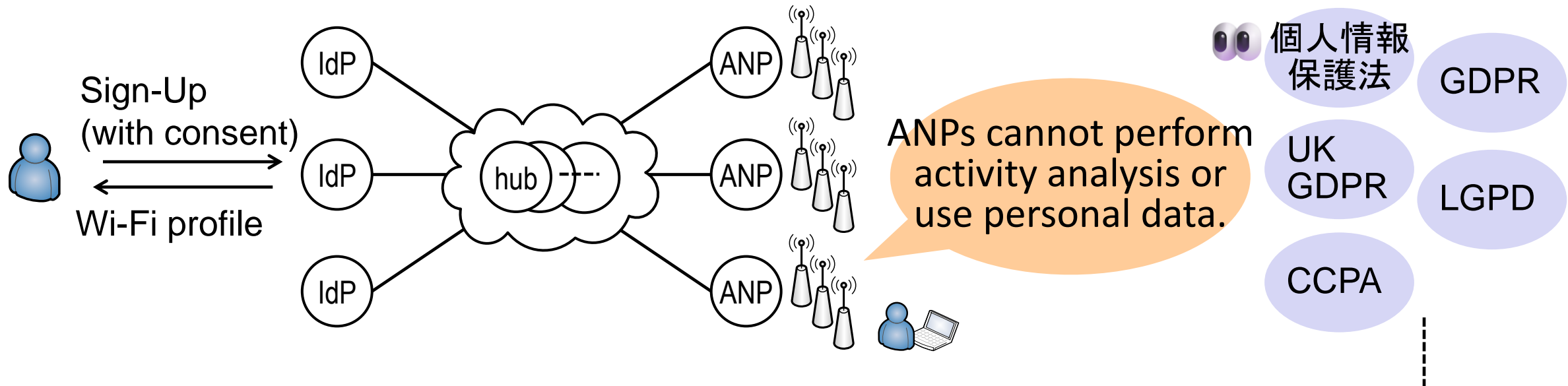
- Owners want to know / do ...
 - Age group
 - Gender
 - Nationality
 - Language (browser setting)
 - Device/OS (for app development)
 - Wi-Fi usage location and staying time
 - Travel routes (e.g. shop-hopping in a mall, tourist sites), etc.
- Especially, municipalities want to know / do ...
 - Travel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



Important data
for businesses

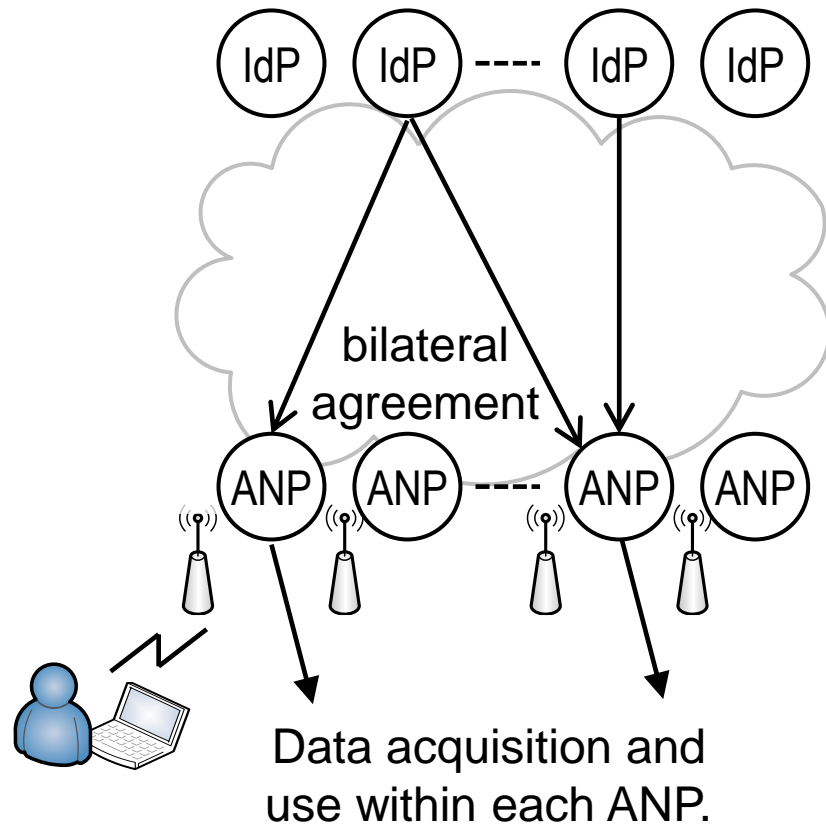
Challenges in user activity analysis and data usage

- 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 from ANPs.
 - EAP-TLS (with TLS 1.3) hides **the contents of Client Certificate.**
 - Ephemeral MAC addresses, etc.



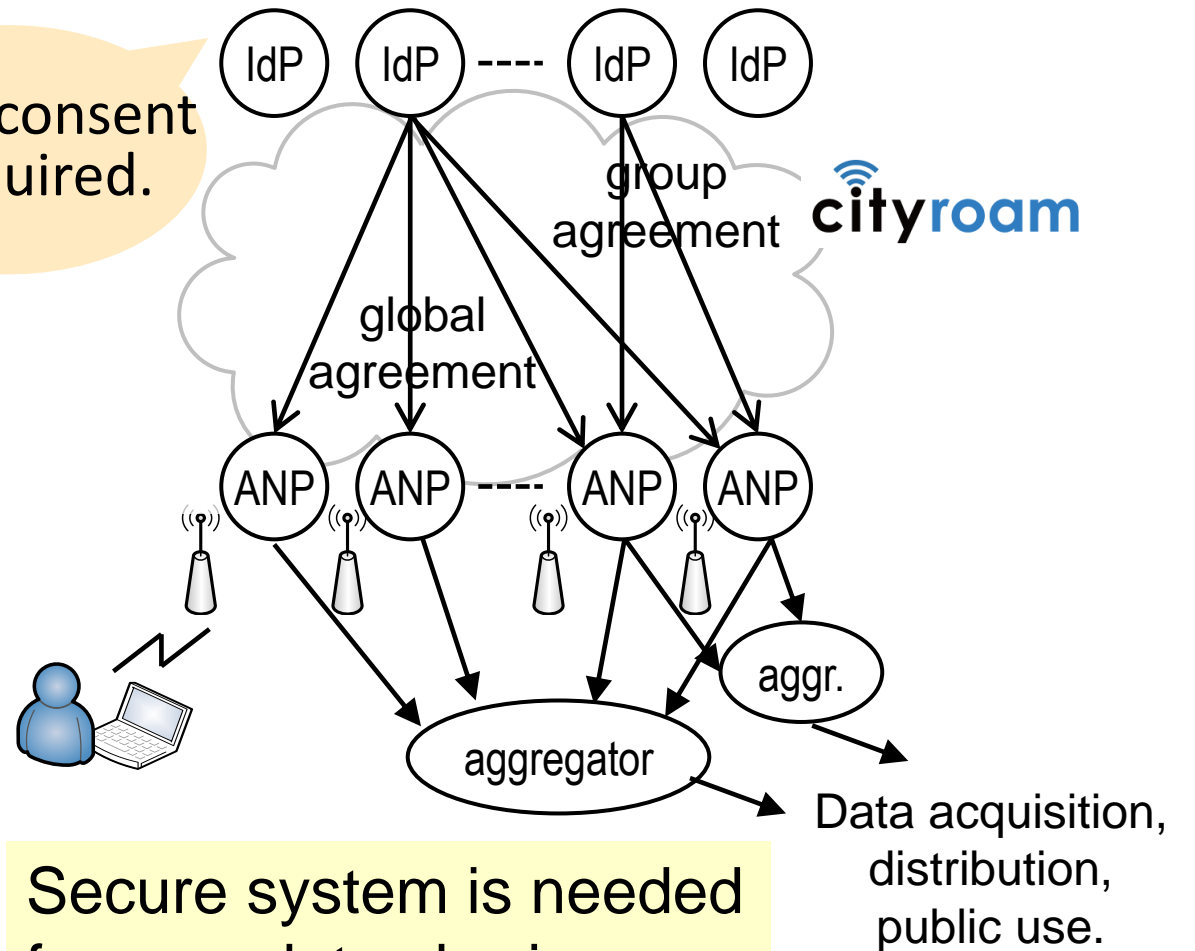
ANP: Access Network Provider
EAP: Extensible Authentication Protocol

Development of a user data sharing system



Bilateral agreements lead to low scalability.

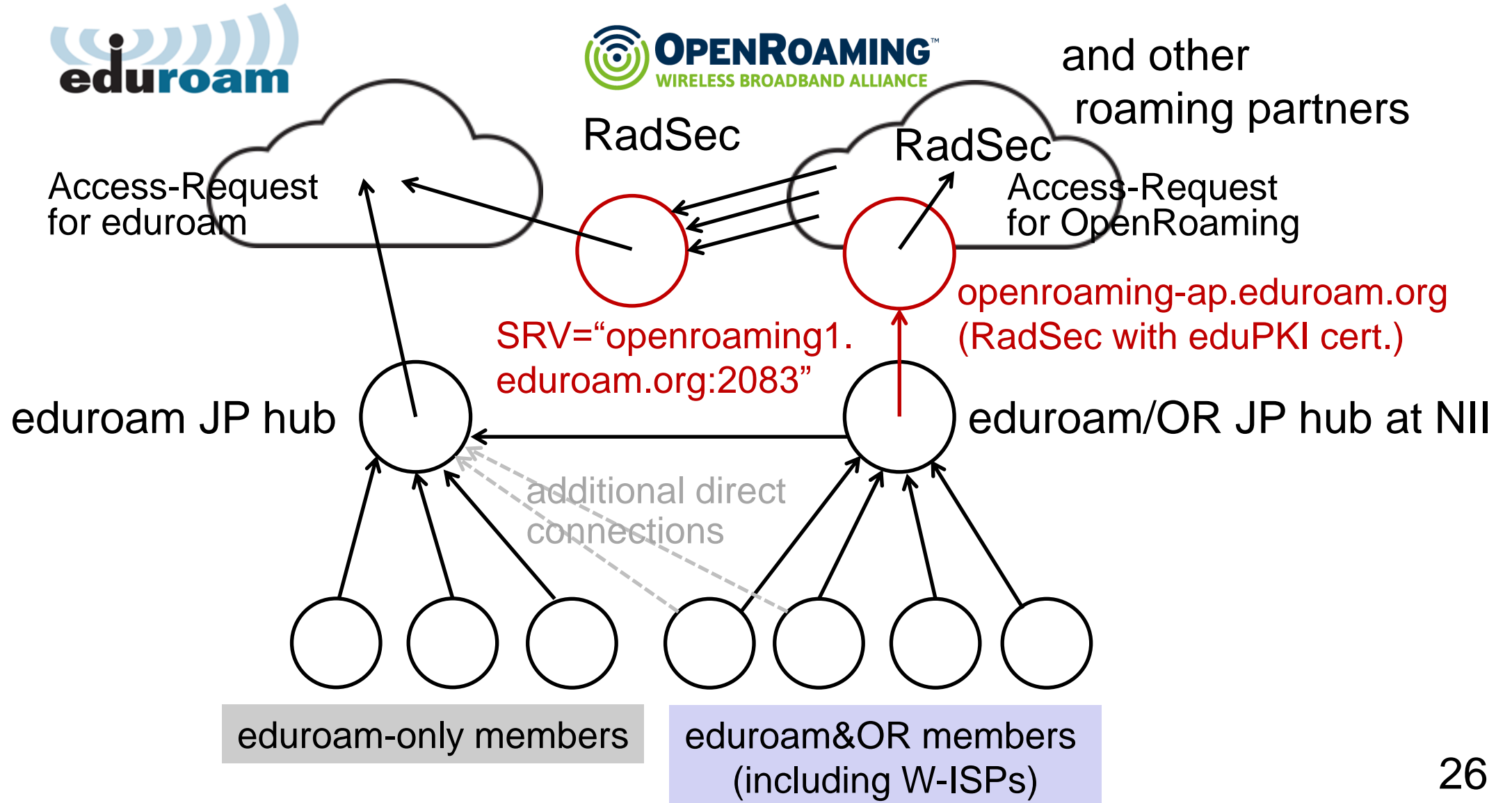
User's consent is required.



Secure system is needed for user data sharing.

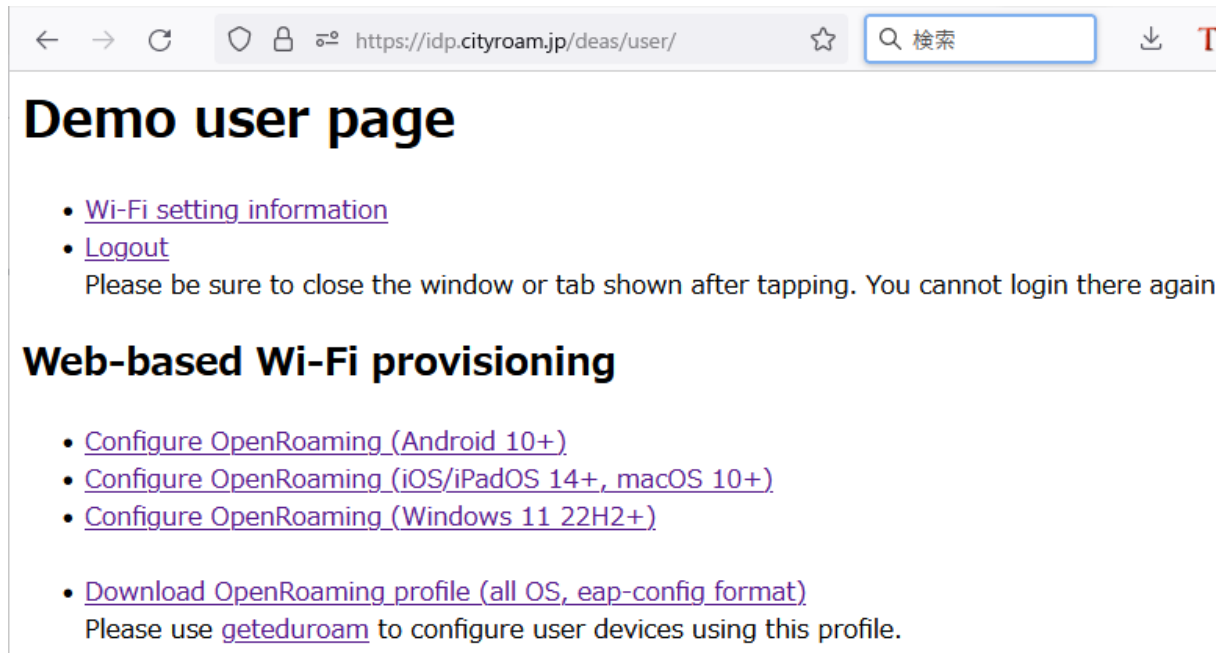
A part of this work is supported by a commissioned research program at National Institute of Information and Communications Technology (NICT) in Japan.

Using the eduroam.org OpenRoaming proxy (under dev.)



Passpoint Provisioning Tools

- Tools and codes that help operators develop their own Passpoint profile provisioning systems.
- The CGI perl scripts allow end users to download Passpoint profiles and configure Wi-Fi **without typing in Wi-Fi ID/password** or certificate.



The screenshot shows a web browser window with the address bar displaying `https://idp.cityroam.jp/deas/user/`. The page title is "Demo user page". It contains two main sections:

- Wi-Fi setting information**:
 - [Wi-Fi setting information](#)
 - [Logout](#)

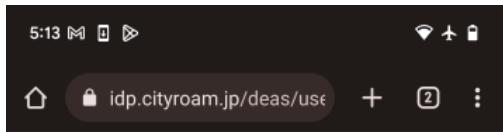
Please be sure to close the window or tab shown after tapping. You cannot login there again.
- Web-based Wi-Fi provisioning**:
 - [Configure OpenRoaming \(Android 10+\)](#)
 - [Configure OpenRoaming \(iOS/iPadOS 14+, macOS 10+\)](#)
 - [Configure OpenRoaming \(Windows 11 22H2+\)](#)
 - [Download OpenRoaming profile \(all OS, eap-config format\)](#)

Please use [geteduroam](#) to configure user devices using this profile.



Profile Provisioning for Android

■ Profile in PPS MO format (w/o signing)

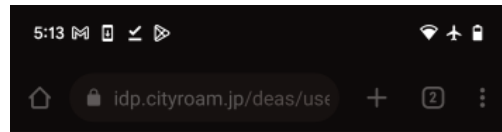


Demo user page

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Web-based Wi-Fi provisioning

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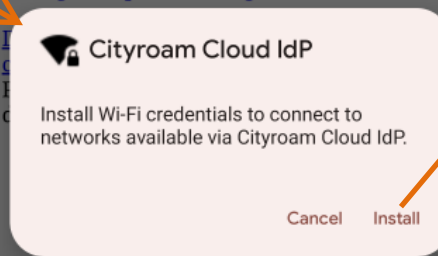


Demo user page

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Internet

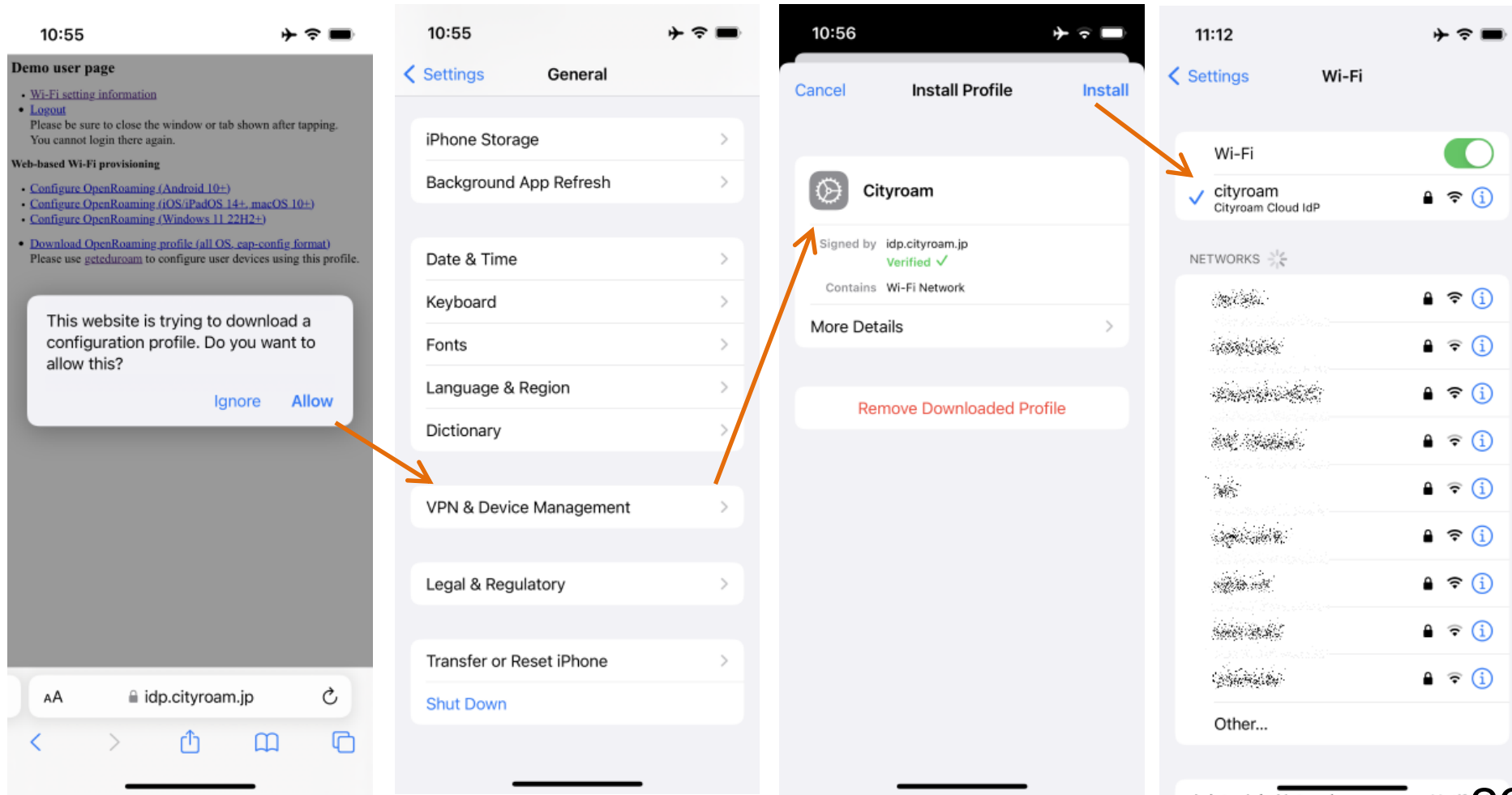
Airplane mode is on

Wi-Fi

- Cityroam Cloud IdP
Connected
- GlobalReach Technology
Saved
- OpenRoaming
Saved
- eduroam
Saved
- [blurred]
- [blurred]
- [blurred]

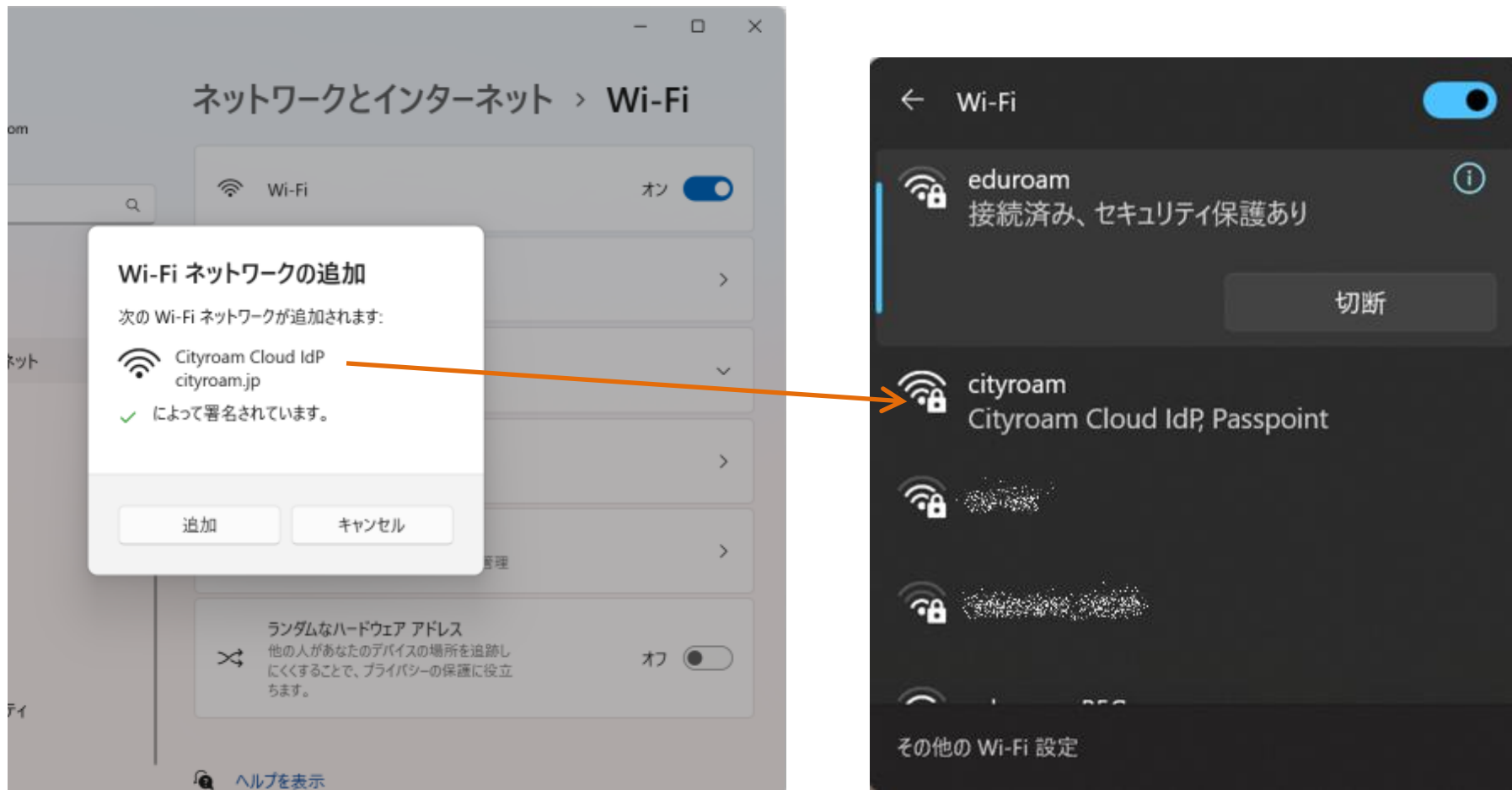
Profile Provisioning for iOS/iPadOS/macOS

- MDM using .mobileconfig
- Signing is optional.



Profile Provisioning for Windows 10/11

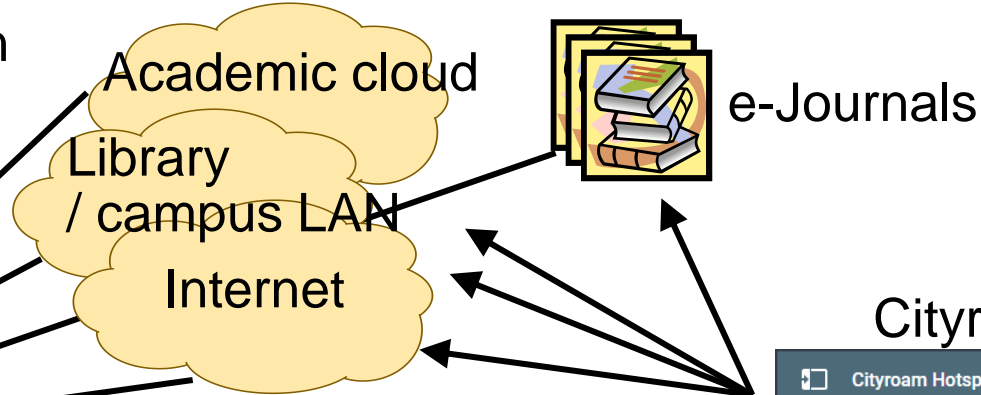
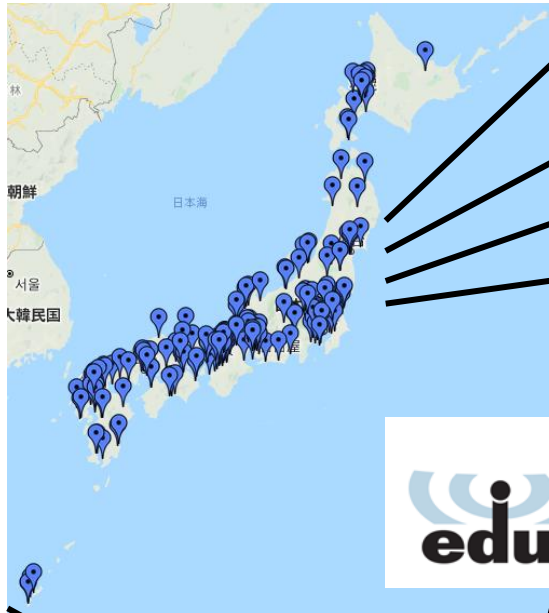
- ms-settings: URI scheme (EAP-TTLS only)
- Signing is required.
(Windows 11 21H2 and older require EV cert.)



Collaboration with Public Wi-Fi services

- Virtual expansion of campus networks.

451 institutions in Japan
(Feb. 2025)



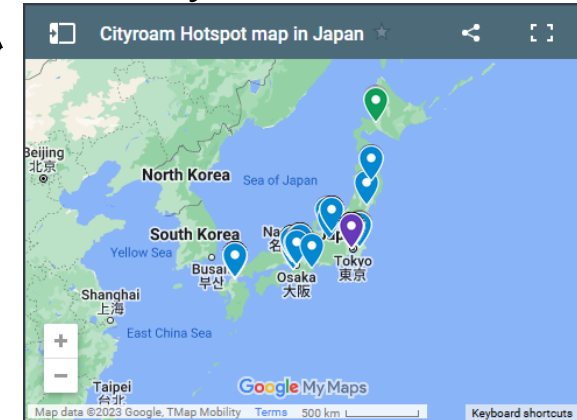
Enable accesses to academic NW and contents from downtown areas



Federation

NW accesses using universities accounts

Cityroam since 2018



130+ in-door APs at cafes, conference sites, large shops in and around Tokyo (2011-2020)



104 countries worldwide