THE 9-1-1 ASSOCIATION

International Seminar on Mechanisms and Tools of Cooperation on Emergency Services in the Americas

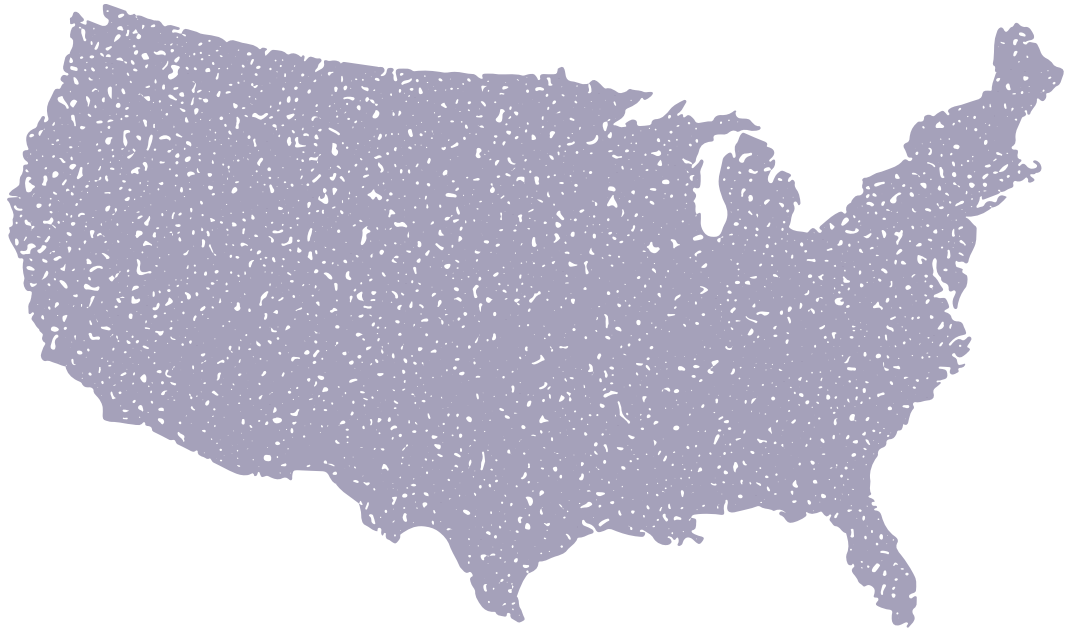
Brandon Abley
Director, Technical Issues
babley@nena.org

About NENA

- NENA: the 9-1-1 Association is THE standards, policy, advocacy and education organization for 9-1-1 in North America and beyond
- NENA has over 14,000 members and growing
- NENA technical and operational standards govern how 9-1-1 and NG9-1-1 systems work across the United States and the world
- NENA is the only open-standards organization dedicated to 9-1-1 issues

9-1-1 in the United States

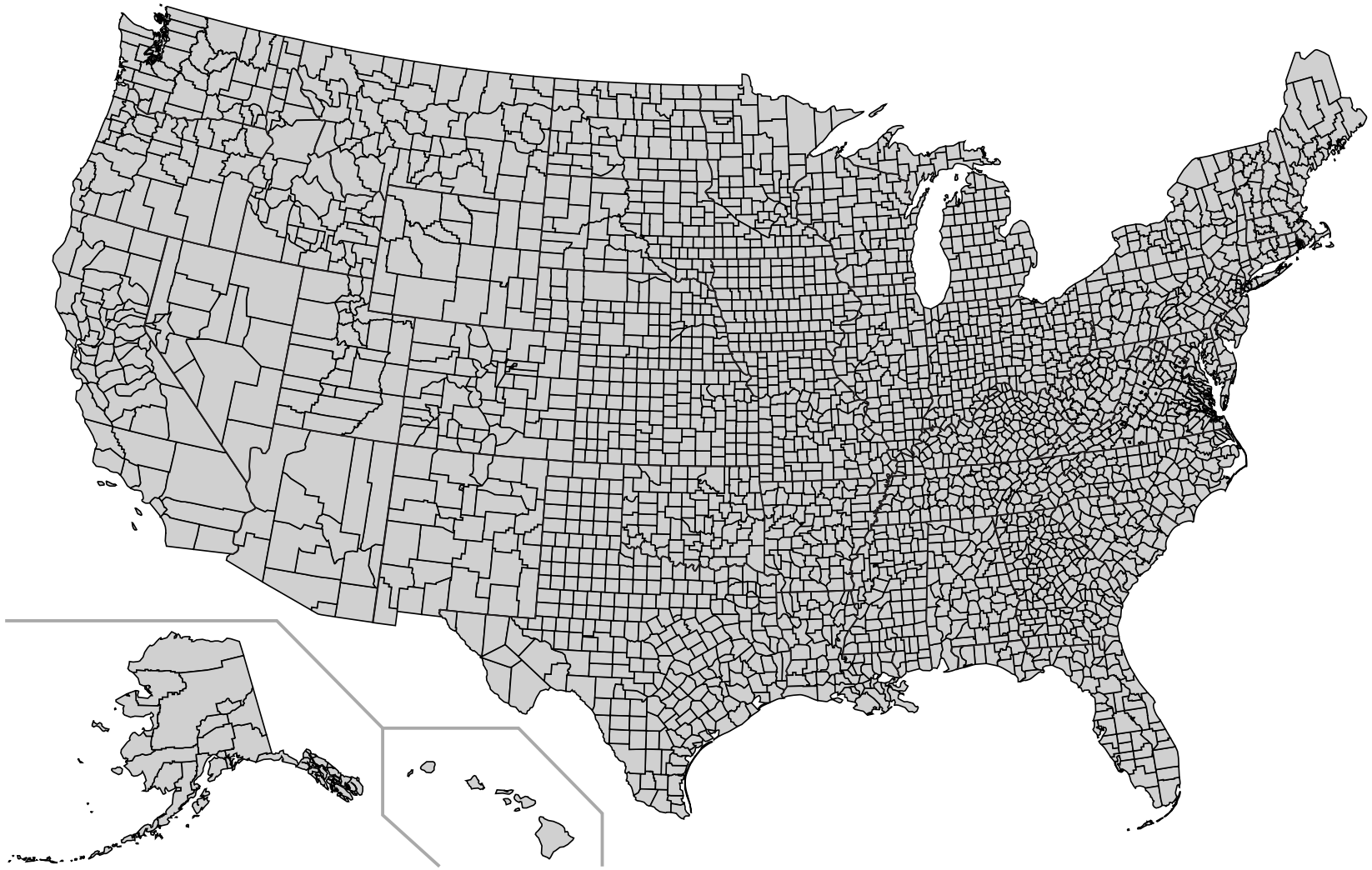
- 9-1-1 is the universal number to reach emergency services in the United States, Canada and Mexico
- In USA, enforced both by statute (state and national law) as well as regulatory (Federal Communications Commission)
- European/Asian equivalents: 1-1-2, 9-9-9
- In many cases, dialing the emergency number for another nation will transfer the caller to the correct service (e.g., dialing 1-1-2 in USA will work as 9-1-1)



Key Challenges in USA

- Number of PSAPs: over 6000 PSAPs
- Number of jurisdictions: thousands of jurisdictions for 9-1-1 purposes
- Lack of interoperability: 9-1-1 service is the responsibility of competitive private industry and state and local government, so there are many different systems in the country; for 9-1-1, USA is like 56+ countries, not one
- Uneven funding: every locality has a different funding levels, not always fair
- Legacy Networks: by deploying a single emergency number service early (1960s!), USA has to support very old technologies in addition to modern ones

Over 3000 jurisdictions for 9-1-1 purposes



9-1-1 Issues are Complicated in USA

- USA has had 9-1-1 as a universal telephone number for over 50 years
- 9-1-1 is considered an essential service in the US; any failure of 9-1-1 is highly publicized and the public considers the service as **always on**
- Due to its long service life, USA 9-1-1 has many legacy technologies to support
- With over 3000 counties that each have some individual control over how 9-1-1 is handled in each jurisdiction, political and funding issues are diverse
- For 9-1-1 purposes, USA is like 56 or more countries, not one
- These issues are (for better or worse) part of the American Republic system

Key Technical Standards for NG9-1-1

NENA i3

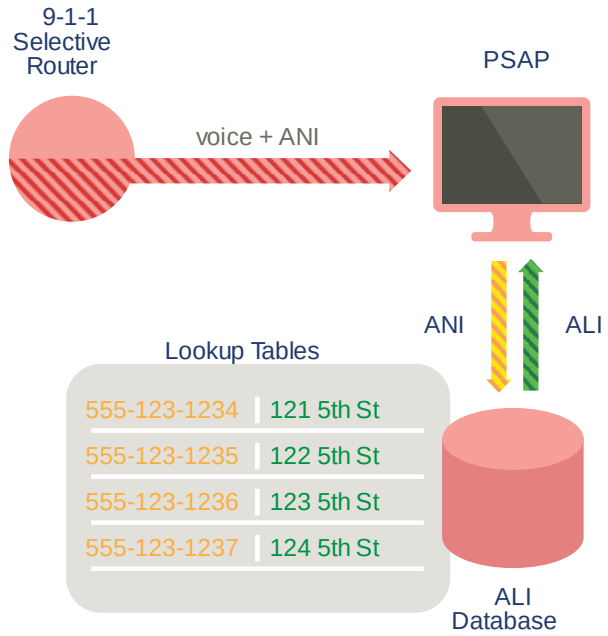
- NG9-1-1 Core services standard
- Developed by NENA
- Basis for International Work (e.g., Europe and Canada)

IETF

- Internet standards: core set of global standards for networks
- Much of i3 is built off of IETF specifications

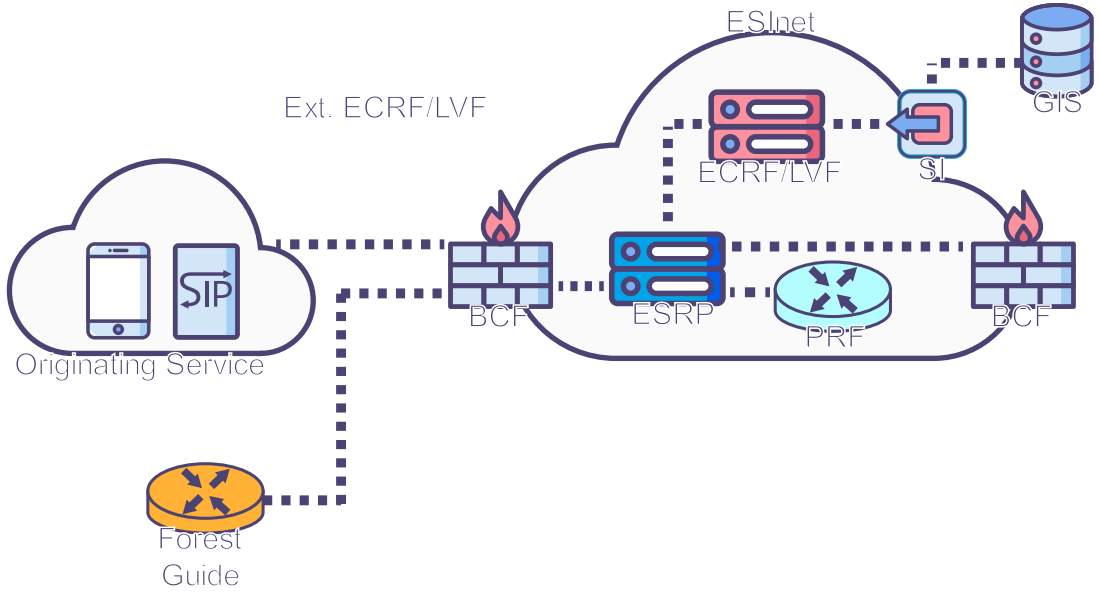
Legacy E9-1-1 vs NG9-1-1

Legacy E9-1-1 (old)



- Telephone calls (TDM)
- Telephone # : address : PSAP
- Additional data over-the-top

NG9-1-1 (new!)

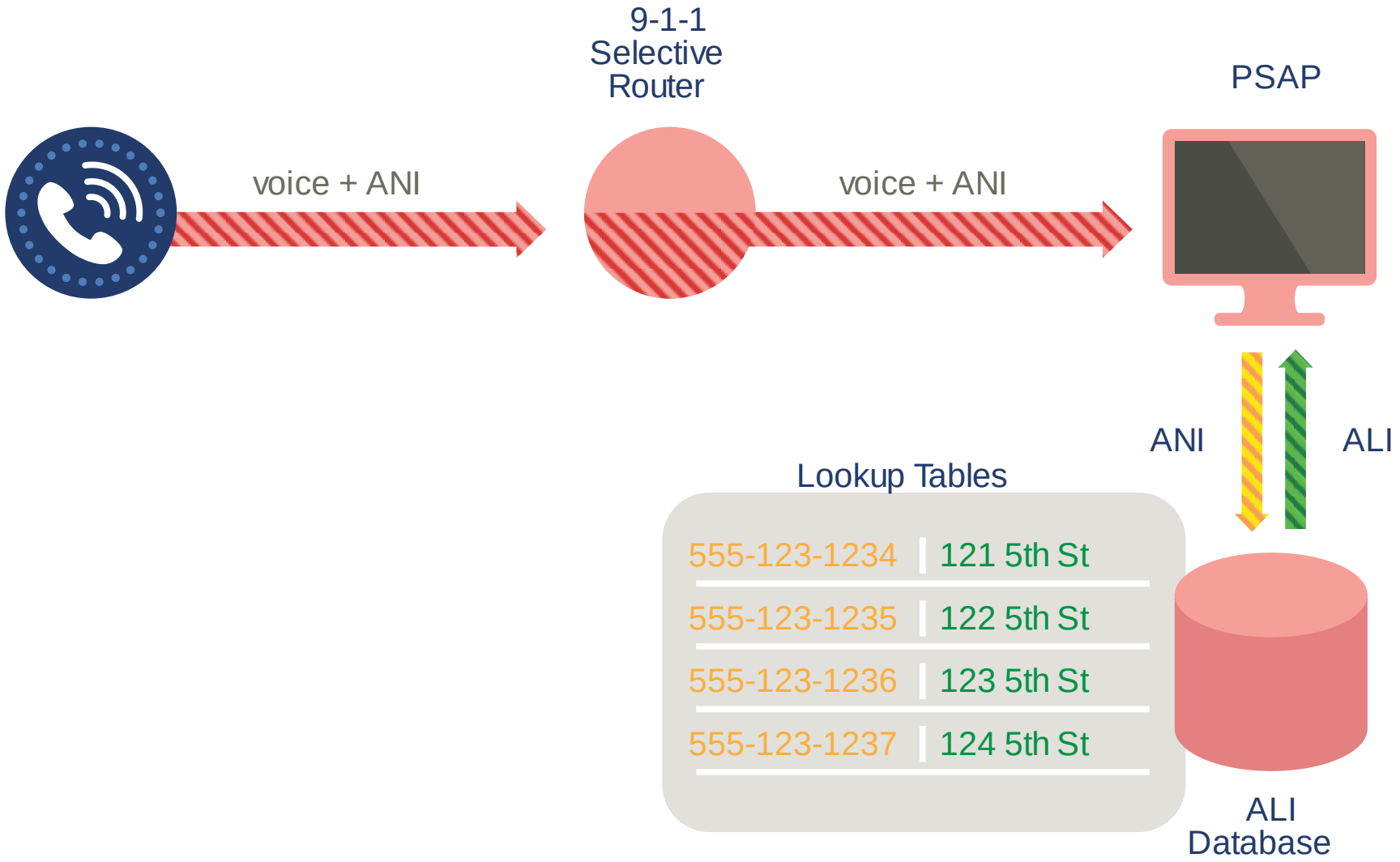


- SIP calls (IP) and multimedia
- Actual Location and GIS-based Routing
- Data included with call

What is Legacy E9-1-1?

- Legacy E9-1-1 is built around telephone calls and addresses
- Telephone numbers are associated with an address, which is used for routing and dispatch
- Routing is done by a Selective Router, like a traditional telephone switch
- Newer technologies (cellular, VoIP) have been added to legacy E9-1-1 systems over many years (not always elegantly)
- While implementing NG9-1-1, US jurisdictions need to support legacy E9-1-1

What is Legacy E9-1-1? (wireline)

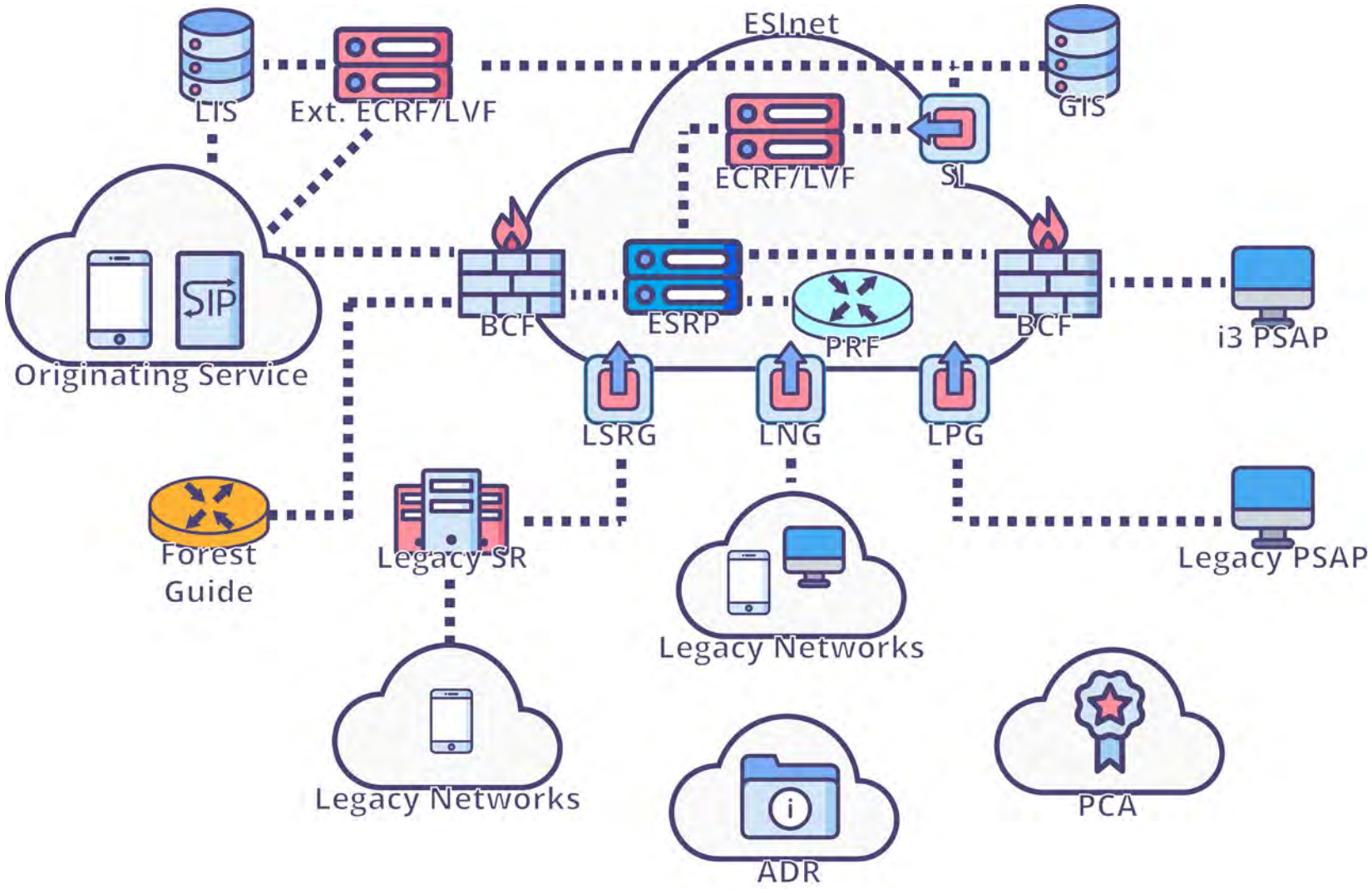


What is NG9-1-1?

- NG9-1-1 is built around SIP and IP (like modern VoIP services/LTE)
- Provides standardized interfaces from emergency call and message services
- Processes all types of calls: voice, text, data, and multimedia information
- Acquires and integrates additional call data useful to call routing and handling
- Delivers calls, messages, and data to the appropriate entity based on the location of the caller and other policies
- Supports data, video, and other communications needs
- Interoperates with services and networks used by first responders

NG9-1-1 (simplified)

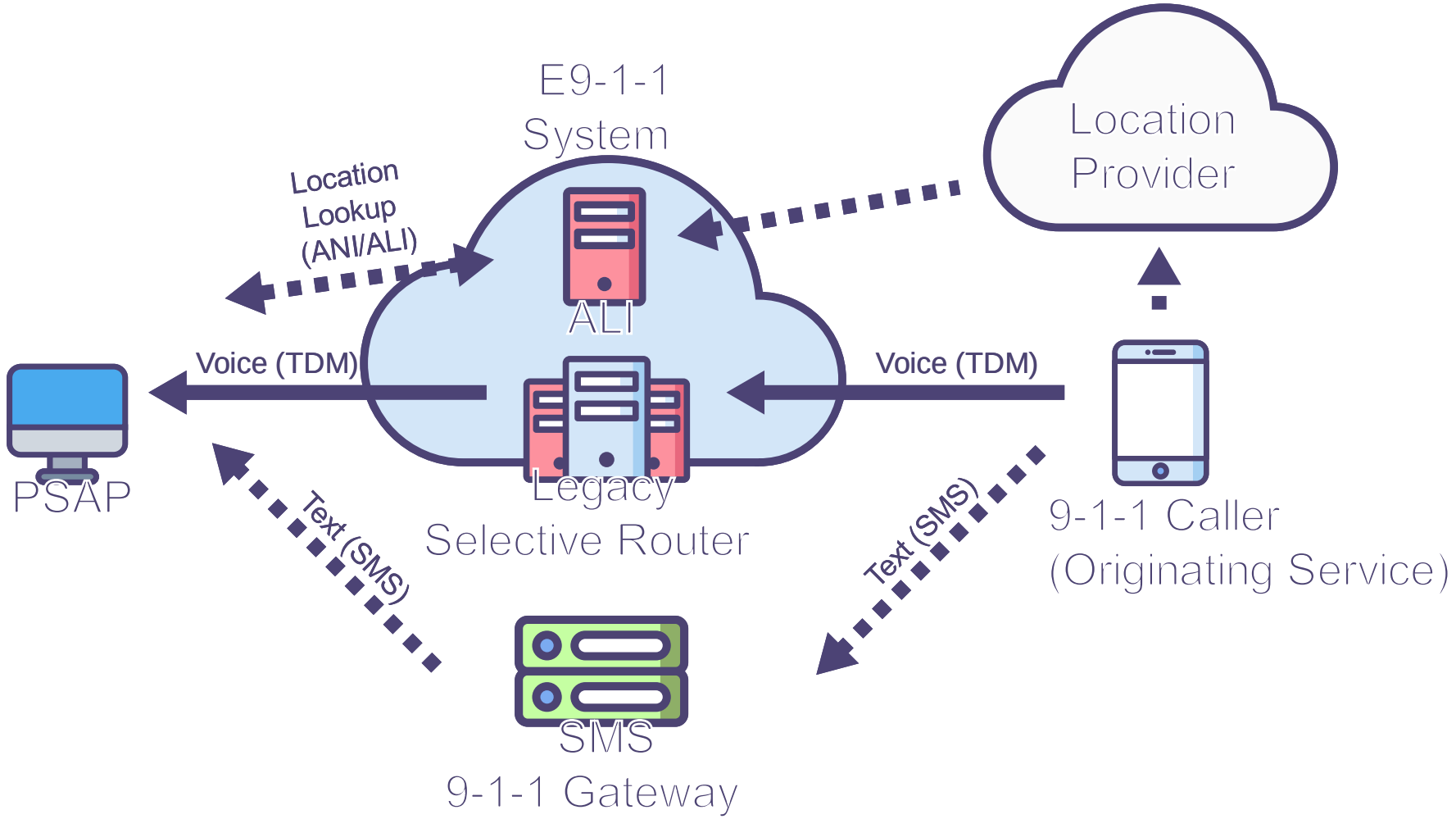
- All-IP and SIP
- Uses same signaling and protocols as LTE
- Routing elements use your actual location
- Legacy gateways for transitional elements
- Interoperability between localities, states and nations



Primary Benefits

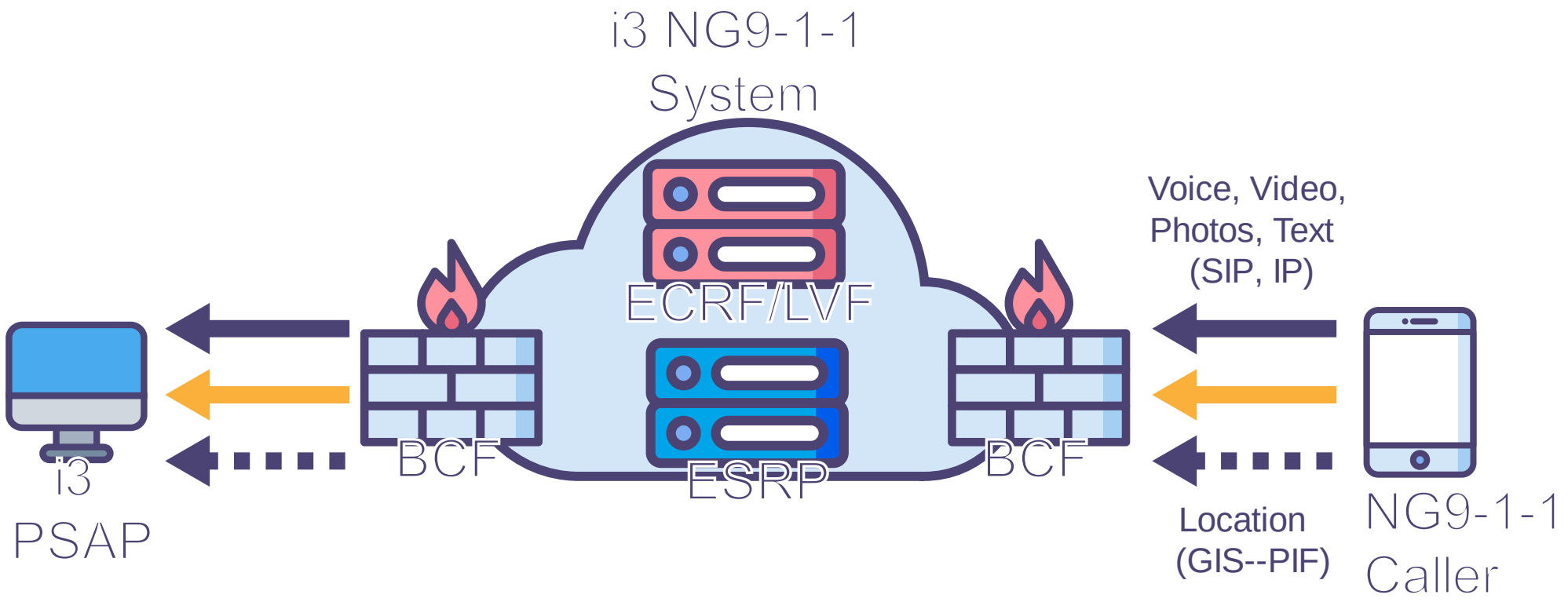
- Location-based Routing and Handling
- Policy-Based Routing
- Modernized, all-IP architecture
- Multimedia Calls
- A Variety of Call Types
- Information Handling (Additional Data)
- SIP call setup

NG9-1-1: Multimedia (IP and SIP) vs E9-1-1



Legacy E9-1-1 is designed for TDM voice (telephone). Location and text are added on.

NG9-1-1: Multimedia (IP and SIP) vs E9-1-1



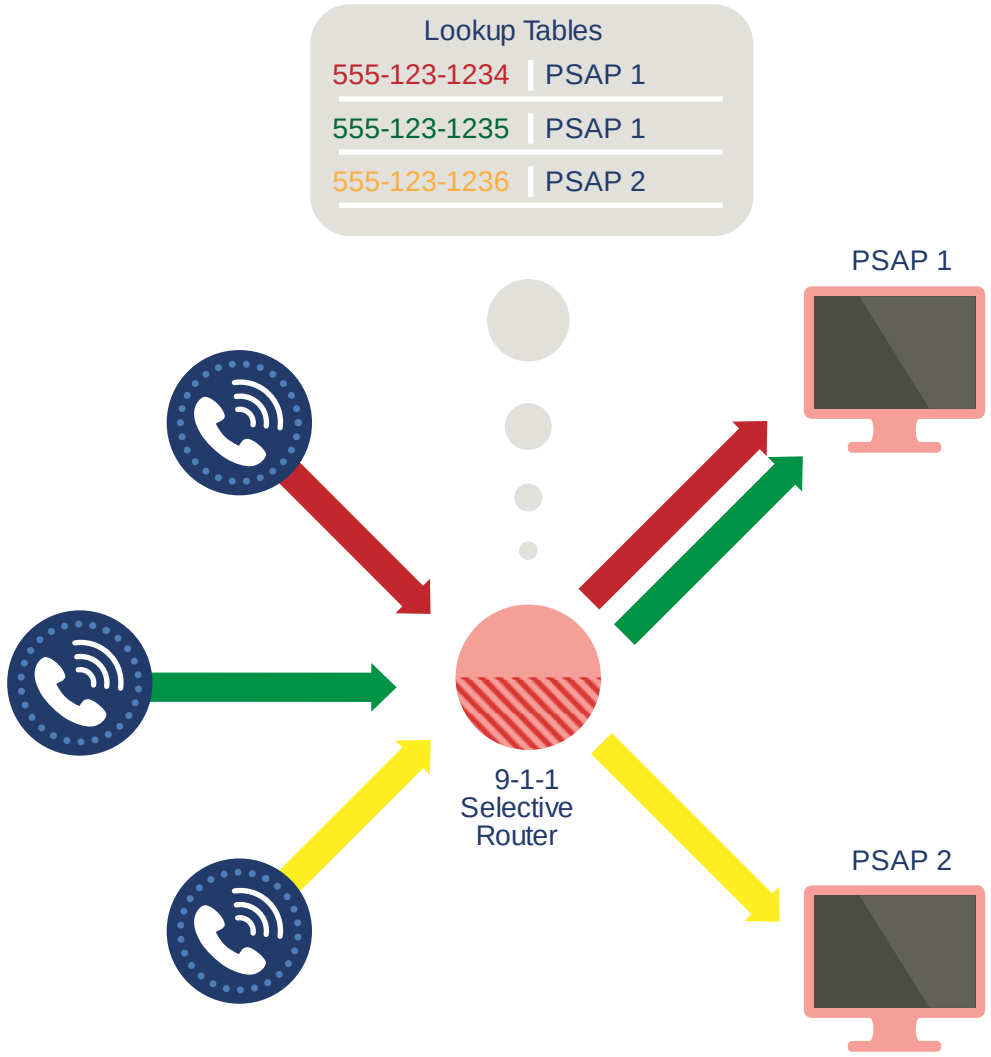
i3 NG9-1-1 is designed to handle rich multimedia and location natively as part of the system.

9-1-1 Location and Routing

- Arguably, location and routing is the **most important** feature of 9-1-1
- A 9-1-1 call must always go to the correct PSAP based on your location
- Location used for routing is generally not the same as the caller's actual location used for dispatching; this may also be true in NG9-1-1
- The mechanism for routing has, for the most part, not changed for decades
- Newer technologies have interfaced with legacy routing technology, and have delivered actual location separately
- This changes under NG9-1-1

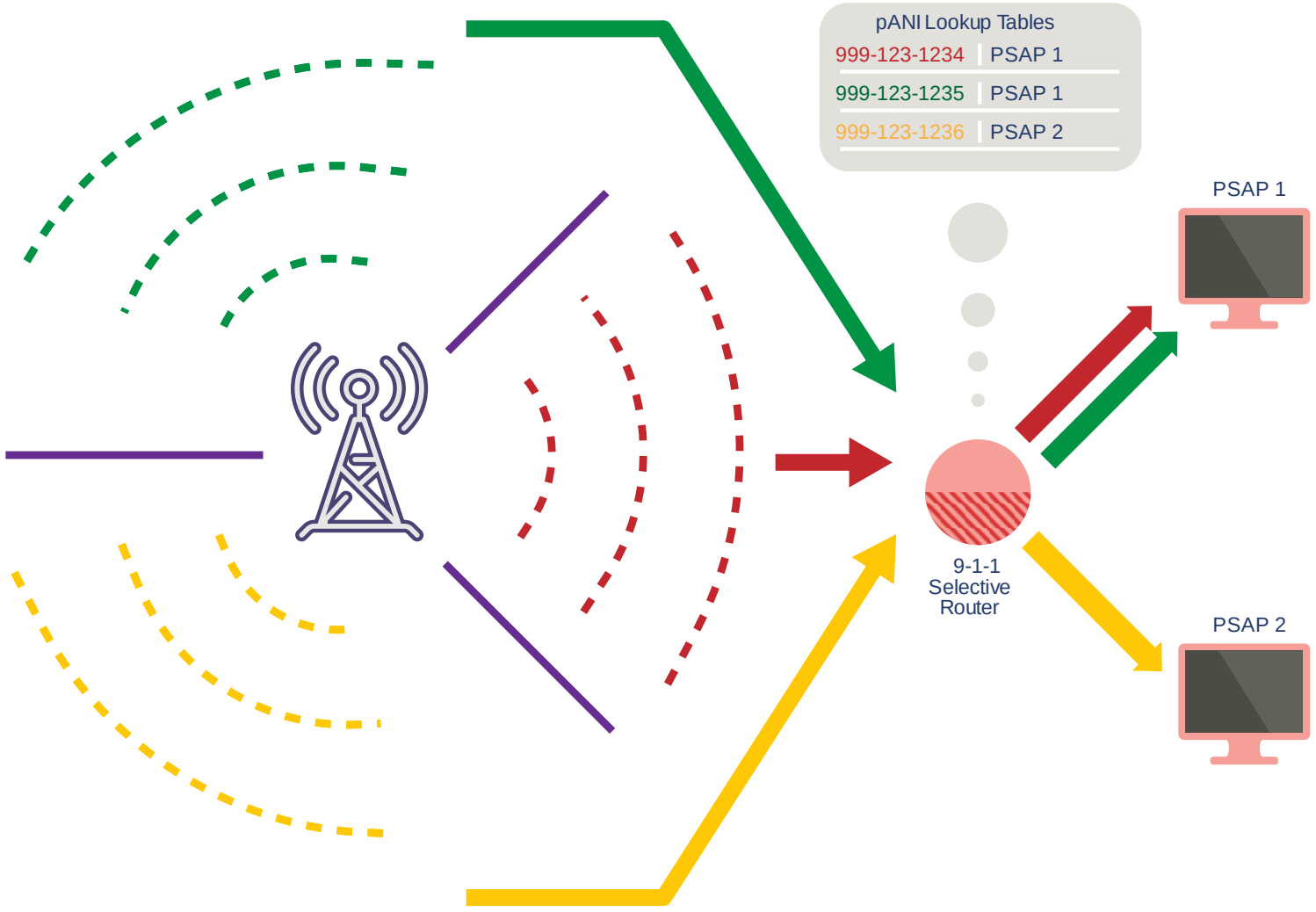
Routing in Legacy E9-1-1 (landline)

- Each telephone number is sent to a specific PSAP
- Telephone numbers and PSAPs are referenced in a lookup database
- 1:1 relationship between telephone number the correct PSAP
- Works for fixed phones, like traditional landline or fixed VoIP

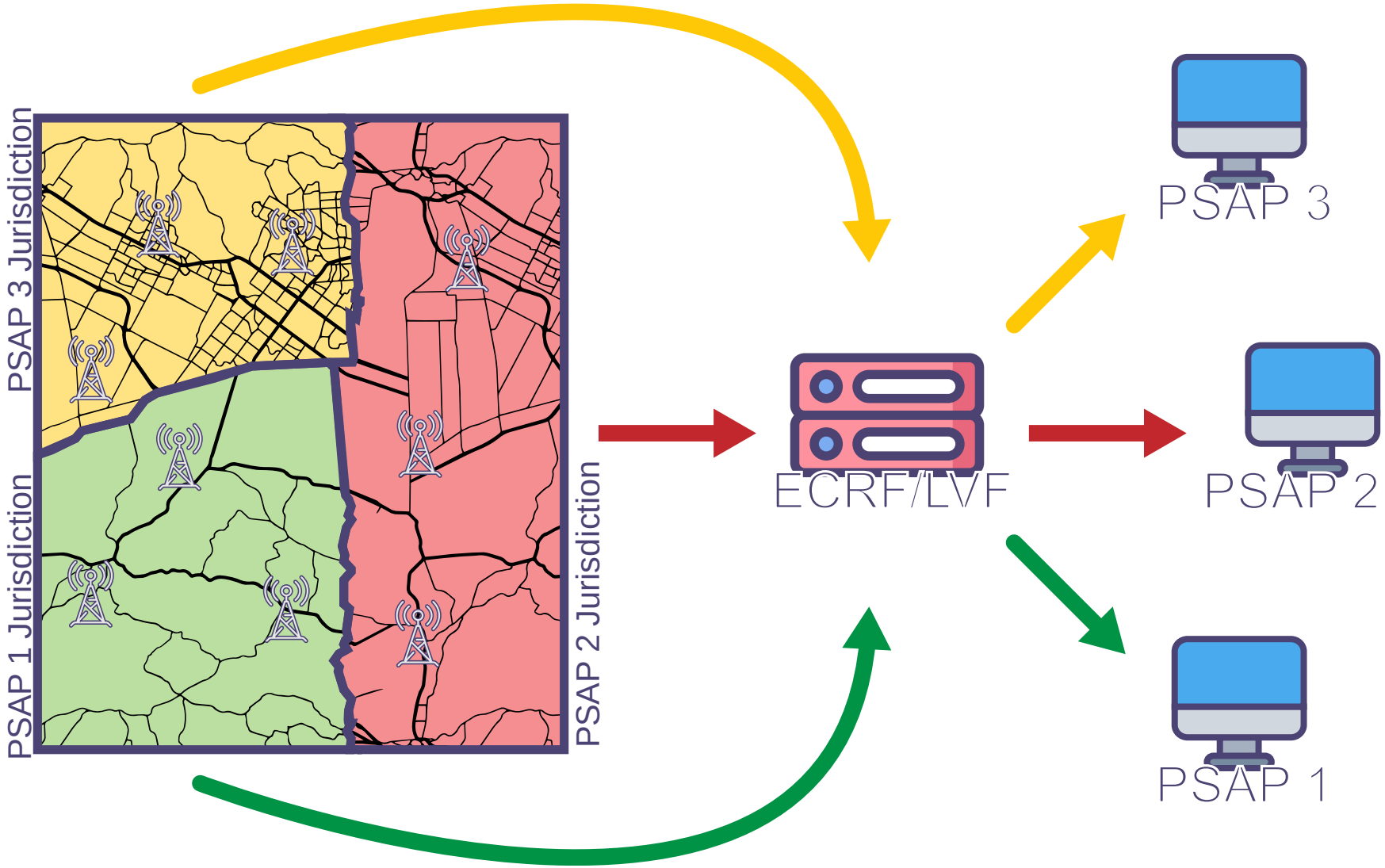


Routing in Legacy E9-1-1 (wireless)

- Cellular is handled with the same mechanism
- Each **cell sector** is assigned to a PSAP through a pANI, or a “fake” telephone number
- Most calls go to the correct PSAP, because usually the cell sector will be contained within one service area

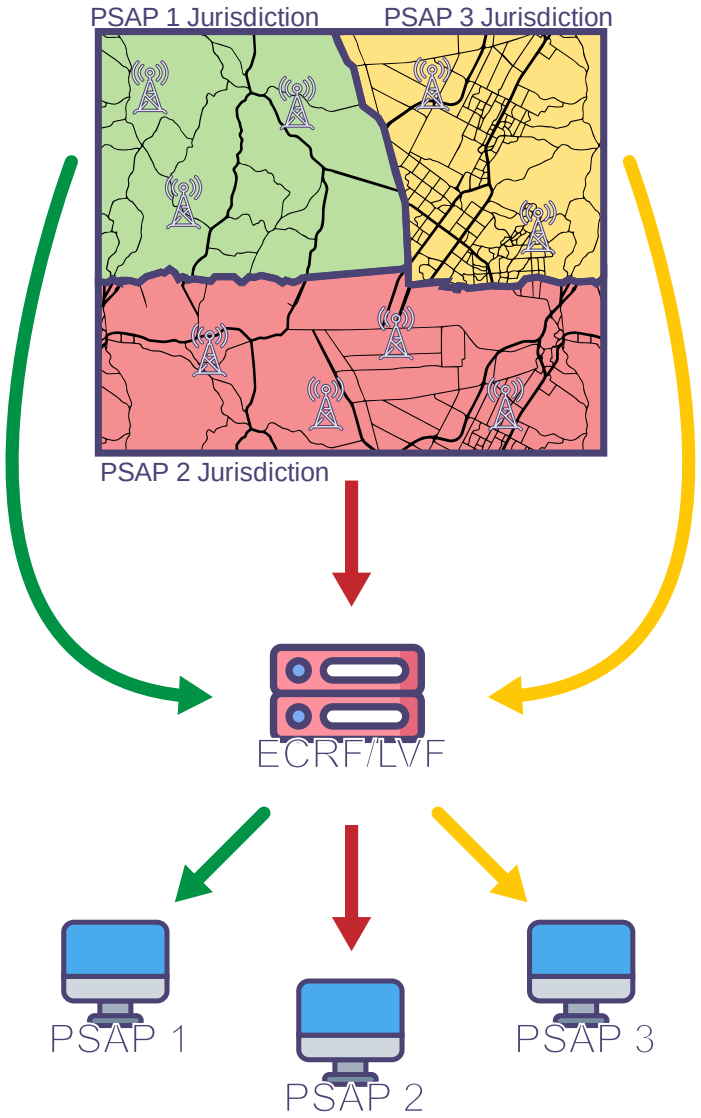


Location-Based Routing (NG9-1-1)



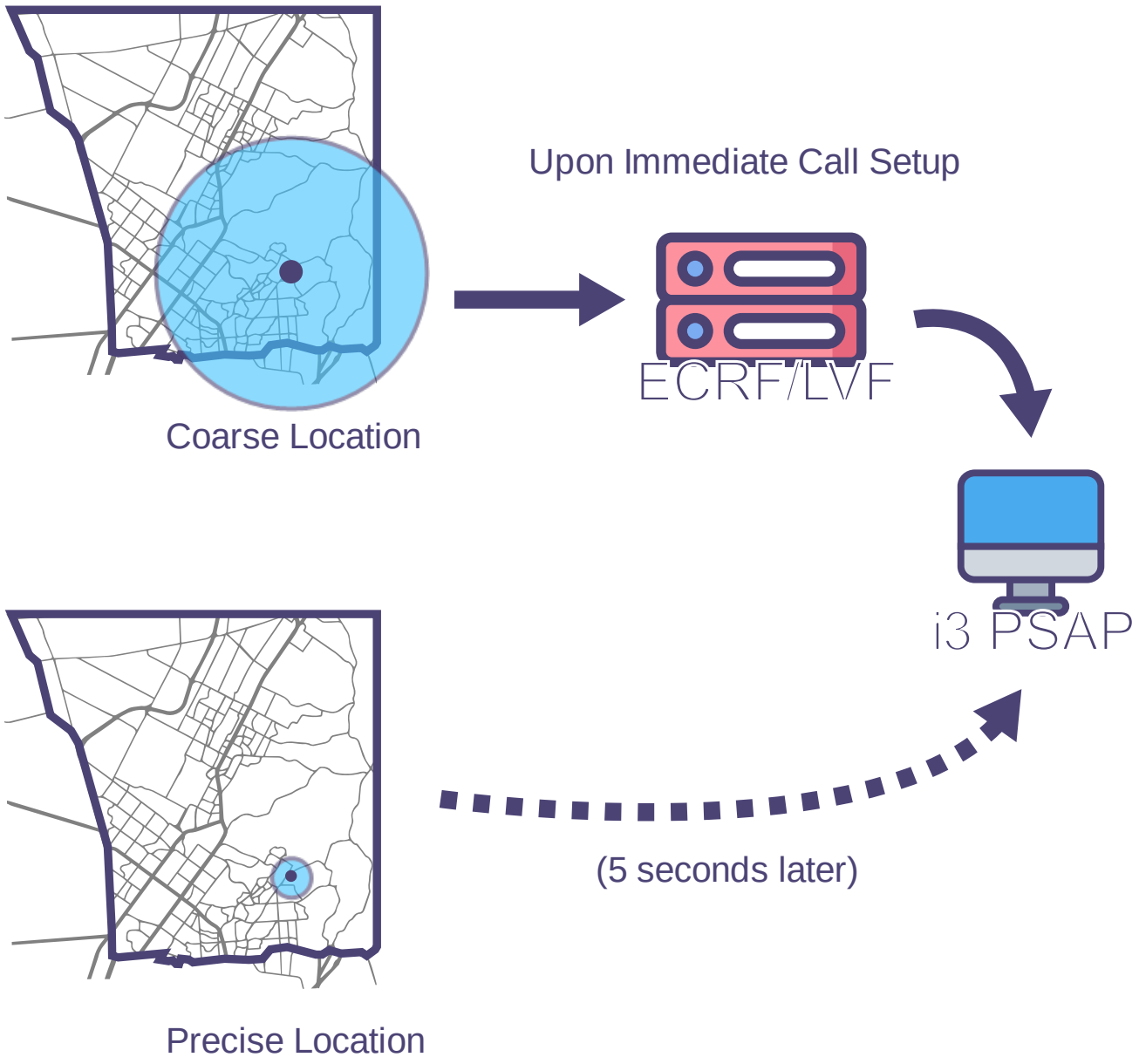
Location-Based Routing (NG9-1-1)

- NG9-1-1 enables location-based routing, in which calls are routing based on the location of the caller and the PSAP for that area
- Provides better accuracy than routing based on cellular sector (E9-1-1) and pANI
- More importantly, provides a single interface for **all technologies** to provide routing to the NG9-1-1 system

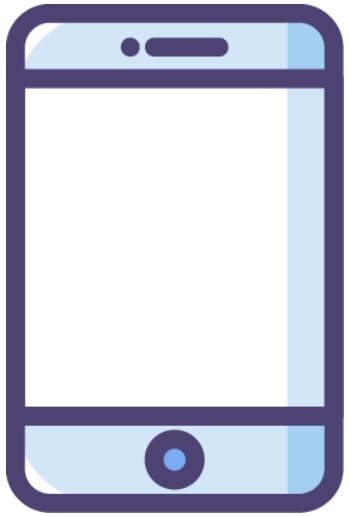


Getting a Fix

- With all technologies, more samples (more time) lead to more precise location
- In NG9-1-1, it is acceptable to route with a *coarse* location; it is likely to reach the correct PSAP and is available immediately
- It will take at least several seconds to answer a call, more to dispatch it
- Precise location can be determined during this time



A look at call types in NG9-1-1



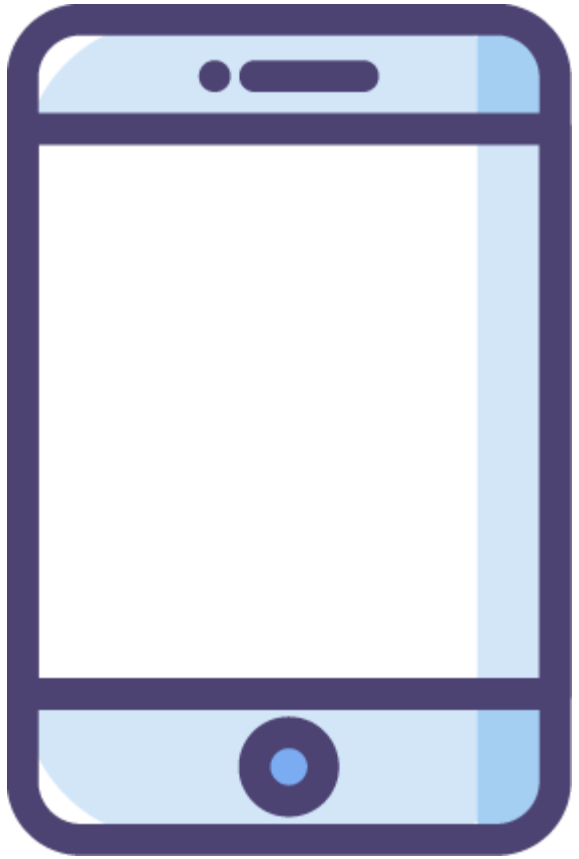
SIP call

Non-interactive Call

AACN

SIP Call

- Conventional call to the PSAP (e.g., dial 9-1-1)
- However, while human-initiated, the call need not be a request for emergency assistance from a phone
- Most calls are envisioned to be audio-only "9-1-1" calls for help, however, other kinds of calls multimedia are supported



Non-interactive Calls

- **Data-only** emergency calls
- Initiated automatically
- Carry Data
- Not necessarily associated with a person
- One-way
- Practical example: Sensors, alarms

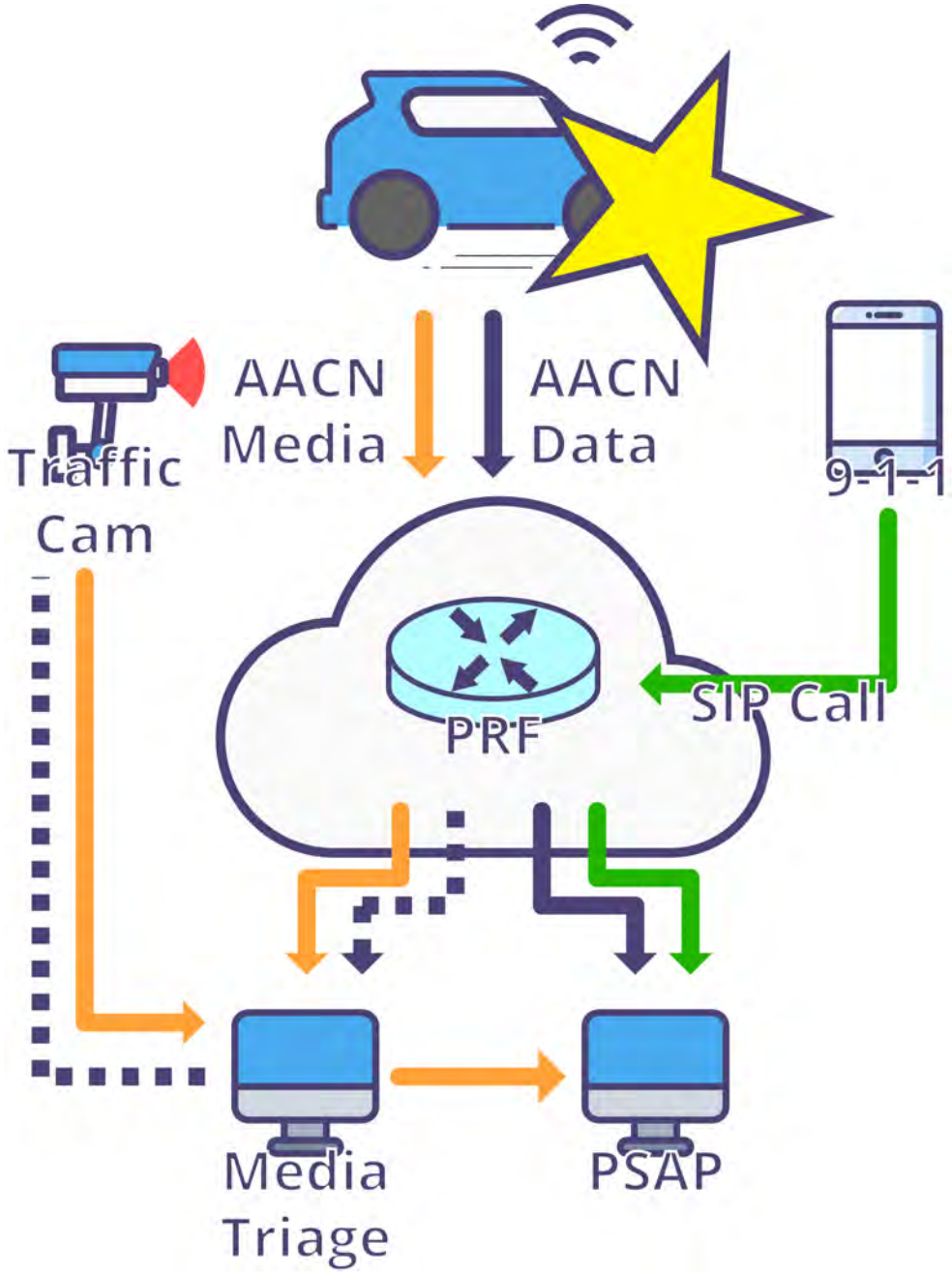
Advanced Automatic Crash Notification (AACN)

- Calls placed by “vehicles”
- A “vehicle” is not always a vehicle
- A “crash” is not necessarily a crash
- Minimum required VEDS dataset is vehicle-centric
- . . . however, AACN data and requests are expandable

Example case with PRF

Example policy: AACN and video media delivered to media triage

- Automobile accident initiates AACN
- PSAP acknowledges call, initiating SIP call with the vehicle
- Both Triage center and PSAP receive notification of the accident, but all video is routed to Triage for screening
- Meanwhile, bystander 9-1-1 call is routed to PSAP



A Call is a Call

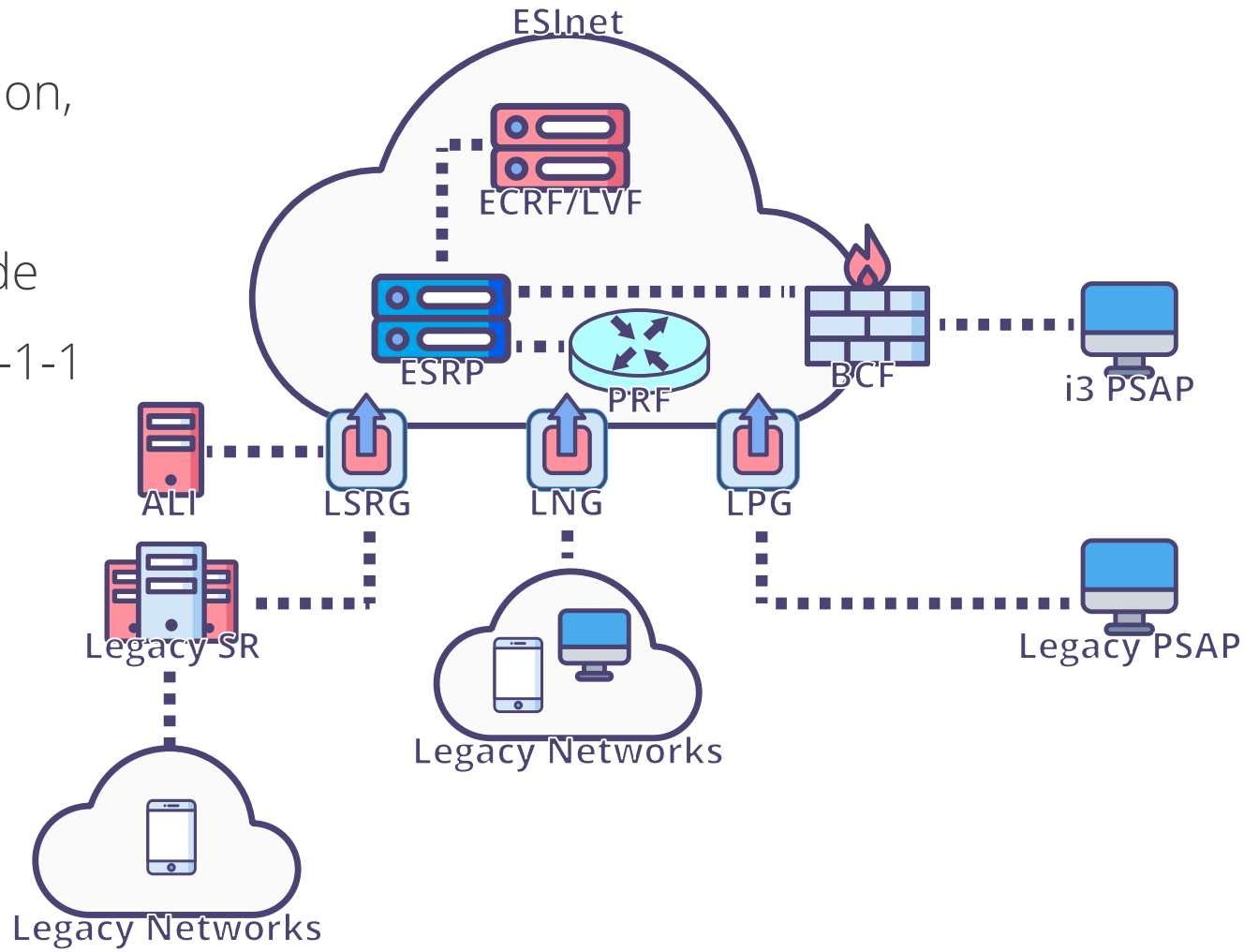
- Version 3 includes a variety of novel call types for NG9-1-1
- Regardless of call type, a call is a call
- The same features, including geospatial or policy-based routing are generally available for all kinds of calls
- The service can be configured to set up any kind of special call for any kind of special destination
- Just because transitional NG9-1-1 doesn't support all of these features, it is still a worthwhile investment to improve 9-1-1 service **today**

Getting to NG9-1-1 is a Process

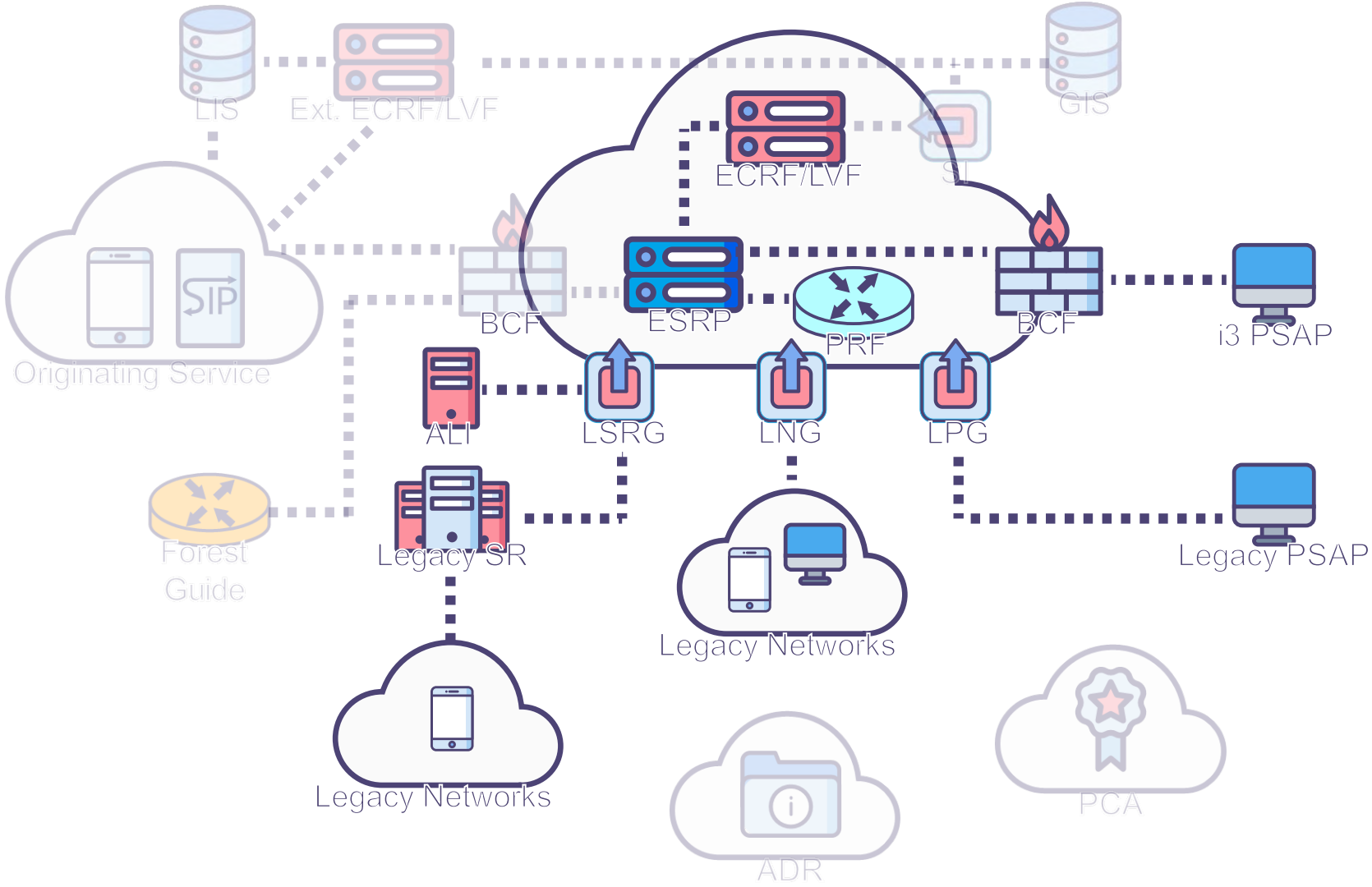
- NG9-1-1 uses SIP and IP instead of telephone numbers and telephone calls
- It is fully compatible with the technologies used by LTE and VoIP providers
- If you do not have legacy E9-1-1 systems to support and statutory authority, you may want to skip to implementing NG9-1-1 right away and requiring service providers to deliver NG9-1-1 calls
- NG9-1-1 providers for important interoperability along political and national borders

Transitional NG9-1-1

- Transitional NG9-1-1 has legacy call origination, but i3 NG9-1-1 inside of the 9-1-1 system
- Allows jurisdictions to operate NG9-1-1 inside of their systems before carriers deliver NG9-1-1 to their customers
- Deployments today (in USA!) operate transitional NG9-1-1
- Characterized by use of gateways:
  - Gateway for Selective Router and ALI
  - Gateway to legacy PSAP
  - Gateway to Legacy network



Transitional NG9-1-1 (showing i3 elements)

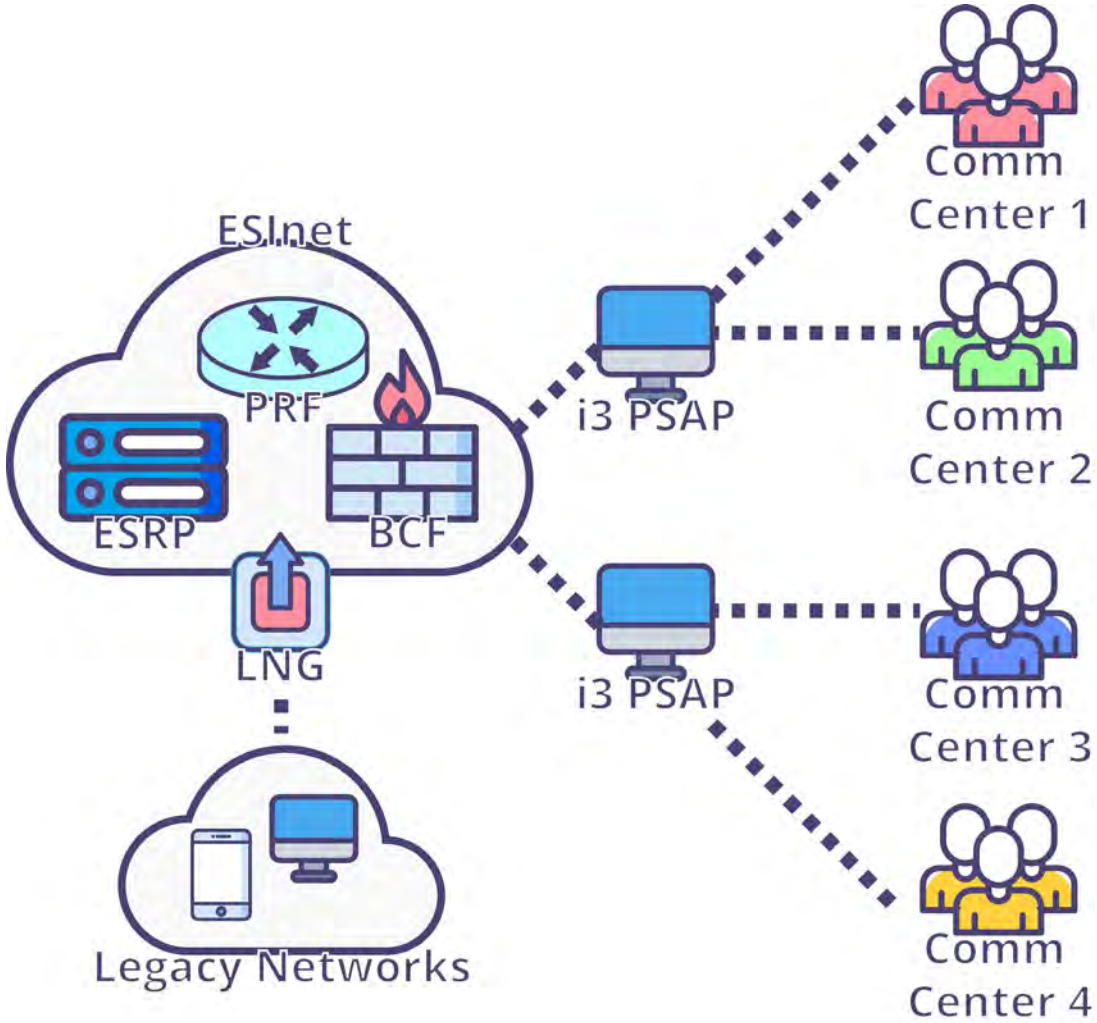


Transitional NG9-1-1

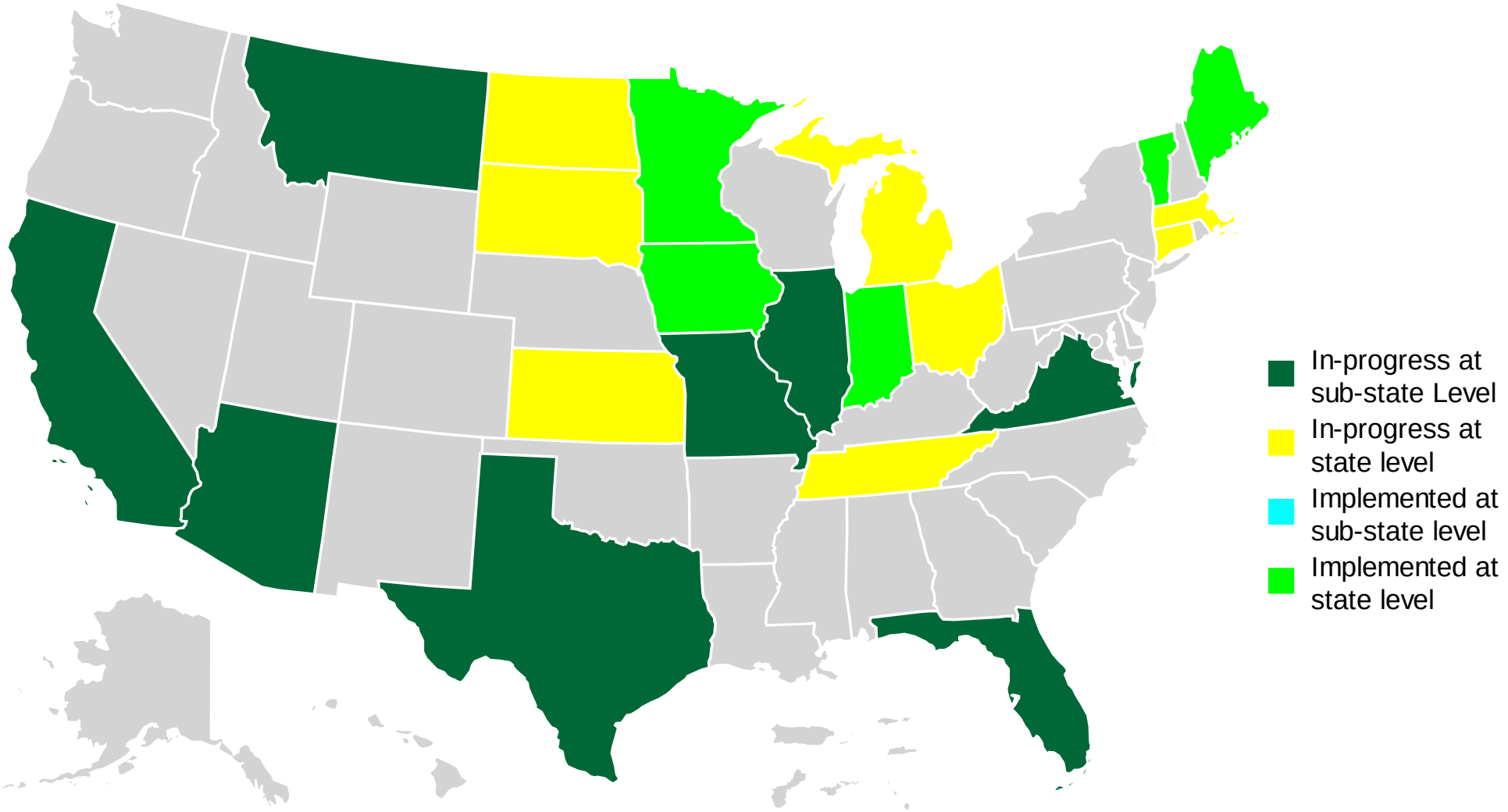
- It is incorrect (and harmful!) to say “there is no NG9-1-1 today”
- Many jurisdictions have invested hundreds of millions of dollars to improve 9-1-1 service by implementing transitional NG9-1-1
- Many benefits from moving to a modern, all-IP architecture, including:
  - Implementation of ESInet (long, complicated project; good to start ASAP)
  - Ready for i3 origination in the near future (chicken or egg: why use i3 origination if there are few systems to connect to?)
  - Greater resiliency, flexibility associated with modern IP architecture

Practical Example Benefit: PSAP as a Service

- In i3, a PSAP is a *service*, not a *place*
- Transitional NG9-1-1 allows one ability to abstract the *place* of the PSAP from the location of communications center
- Benefits of i3 in transitional environment
- Provide for *virtual* backups/consolidation
- Scale/share services over the ESInet
- . . . without immediately affecting management of existing comm. centers



(Transitional) NG9-1-1 Progress Map (2018)



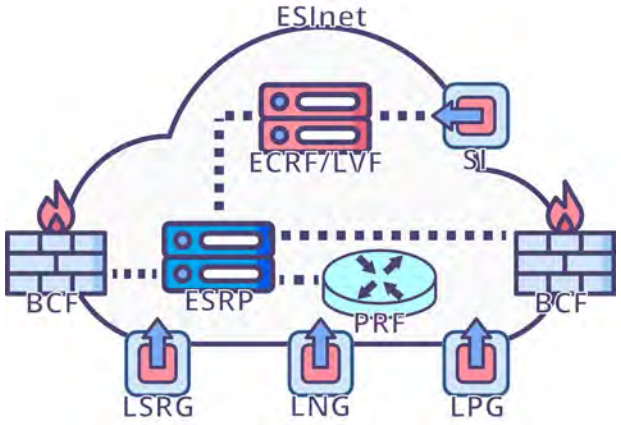
*Based on self-reported data from 2017; this map is not authoritative nor always current

Transitional NG9-1-1 is Valuable

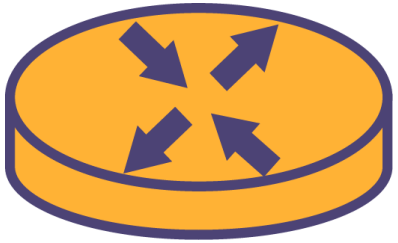
- Throughout the US, jurisdictions have deployed or are deploying NG9-1-1 systems that operate in **transitional** model, connected to legacy networks
- **Some** PSAPs are modern, high-tech facilities; **most** are small facilities with limited staff and resources
- **Transitional model** allows US jurisdictions to be ready for the future while supporting required legacy technologies

Interoperability in NG9-1-1 (Technical)

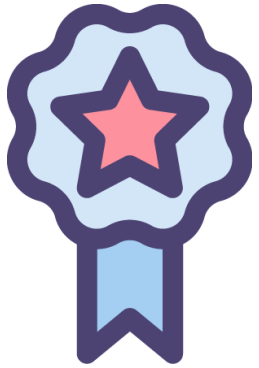
- NG9-1-1 systems are built by many 9-1-1 authorities on many schedules
- Three key features in NG9-1-1 provide for interoperability



Standardized Interfaces



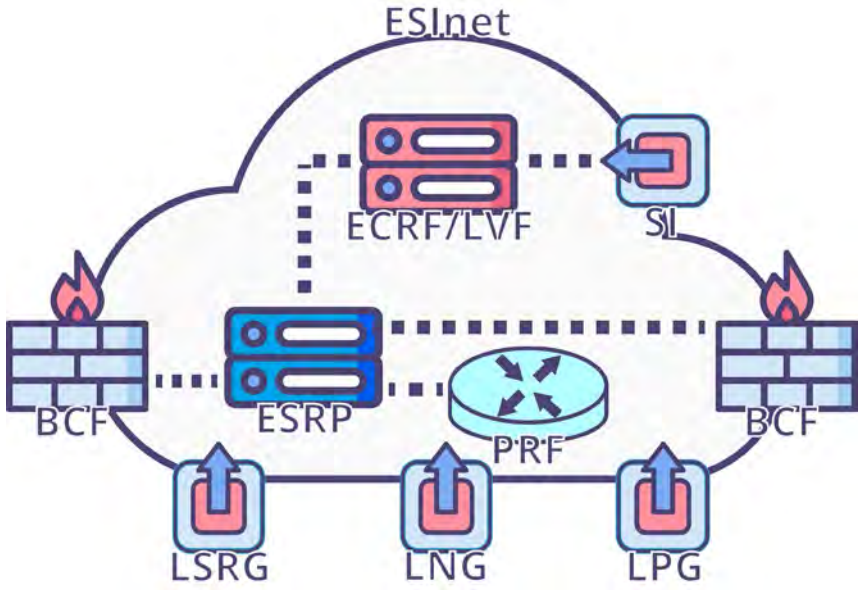
Forest Guide



PCA

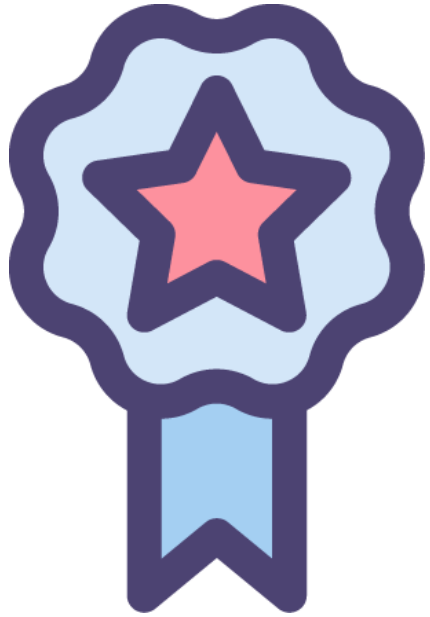
Standardized Interfaces and Protocols

- Standardized interfaces are a key component of technical standards
- Standardization of interfaces and protocols is key to why your WiFi, LTE, Ethernet or other technologies work across vendors and systems
- i3 standardizes how elements and systems interact with each other for NG9-1-1
- Many of these interfaces and protocols incorporated by IETF internet standards, harmonizing much of i3 with the basic definition of the internet



PCA

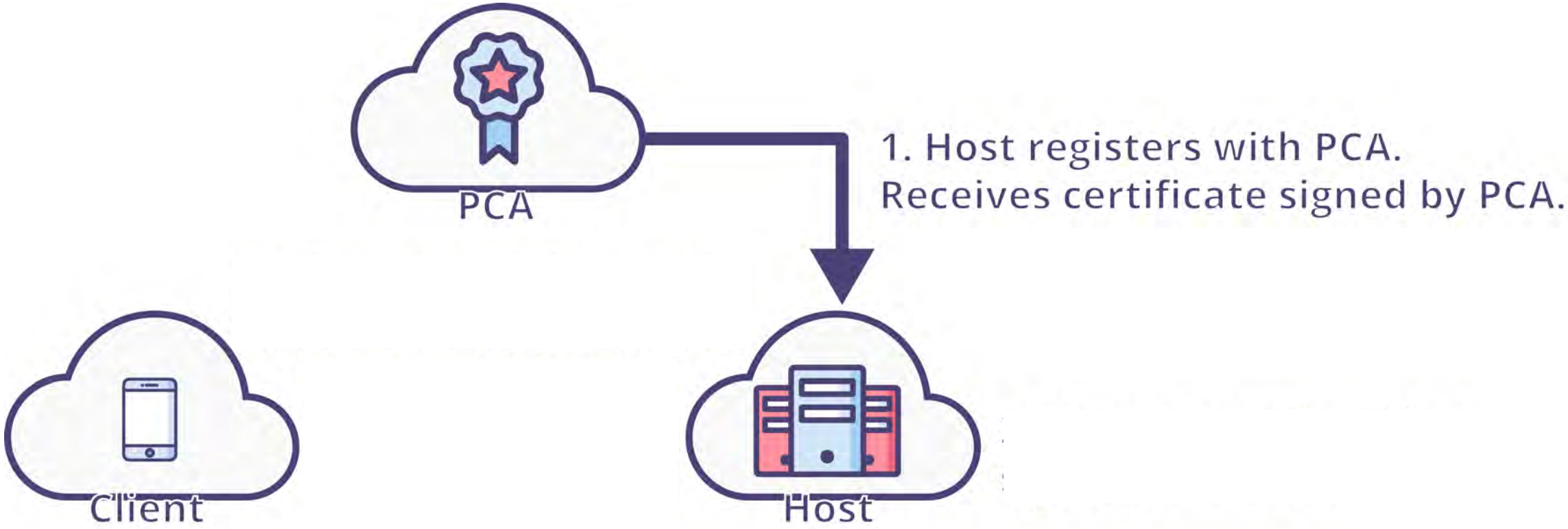
- PSAP Credentialing Authority
- Root of trust for NG9-1-1 and emergency calling
- Required functional element in i3
- Reflects best practice in cyber-security: trust nobody unless validated by a third party
- Not necessarily limited to NG9-1-1
- NENA plans to issue stand up and operate PCA for USA in 2019



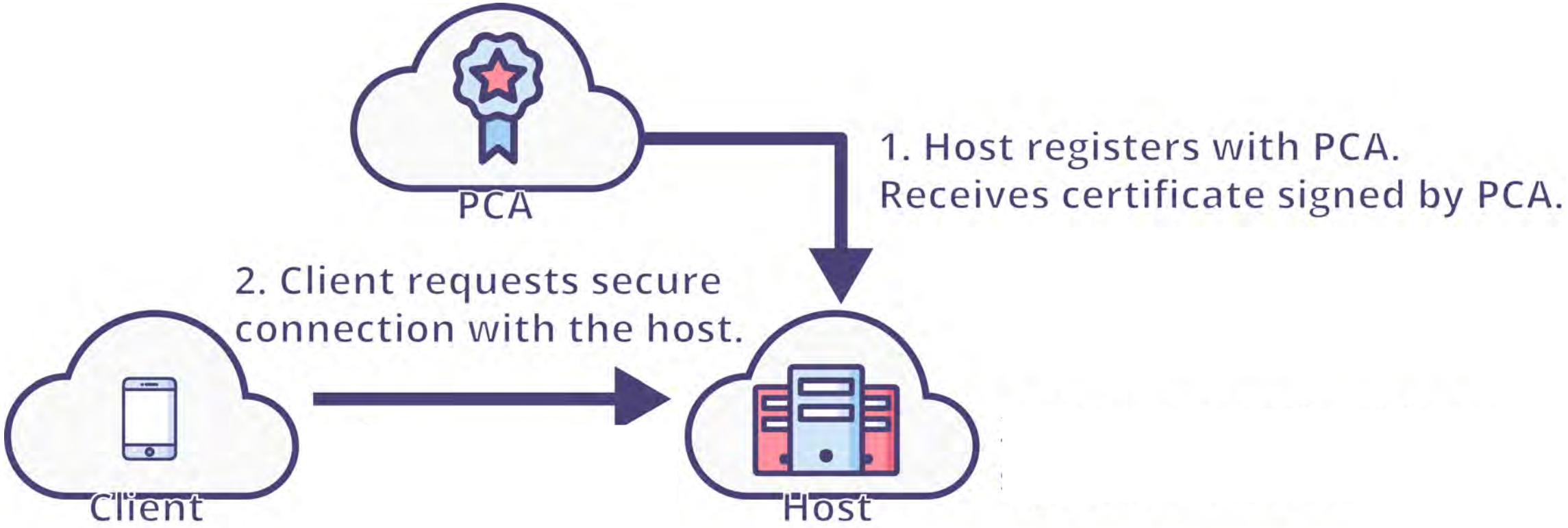
Root of Trust

- Premise: **trust nobody**
- I trust only a specific third party that we have mutually agreed is trustworthy
- This third party is the Certificate Authority. They sign your certificates with a secret key that is cryptographically protected and nobody can duplicate
- If **you** say I can trust you, I should be **more** suspicious you are untrustworthy
- The PCA establishes is this **root of trust** for NG9-1-1
- You know you can safely connect to me without prior planning, because I have a signed PCA certificate that says I am a trusted NG9-1-1 entity

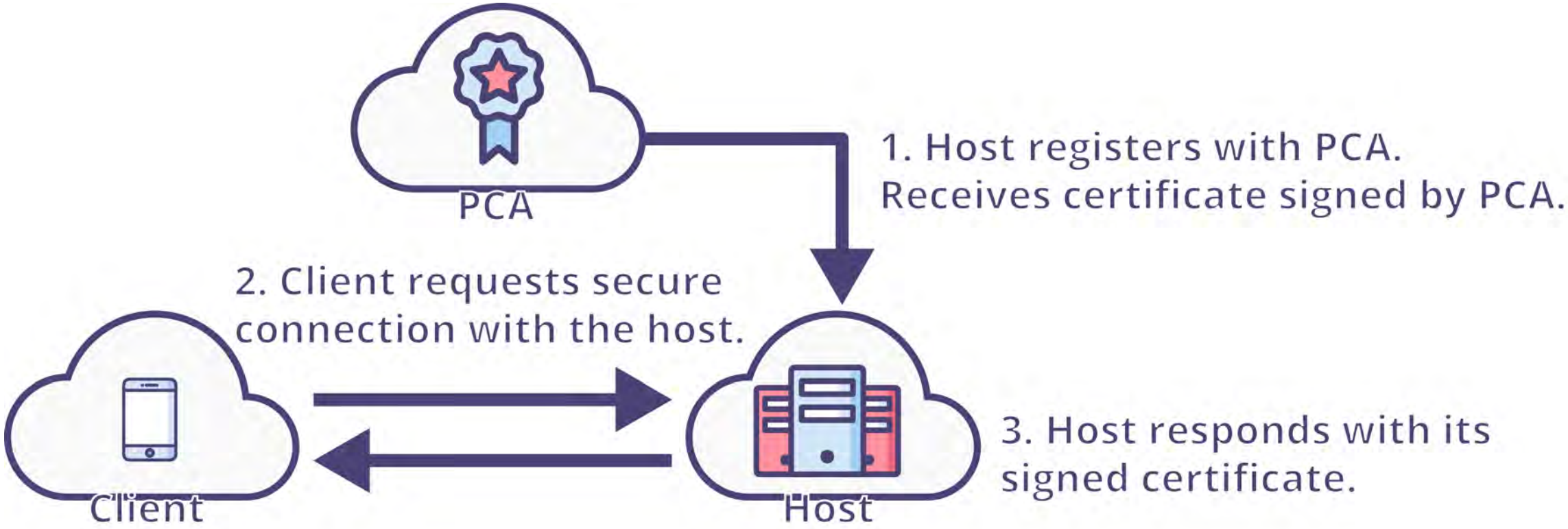
What is a Security Certificate?



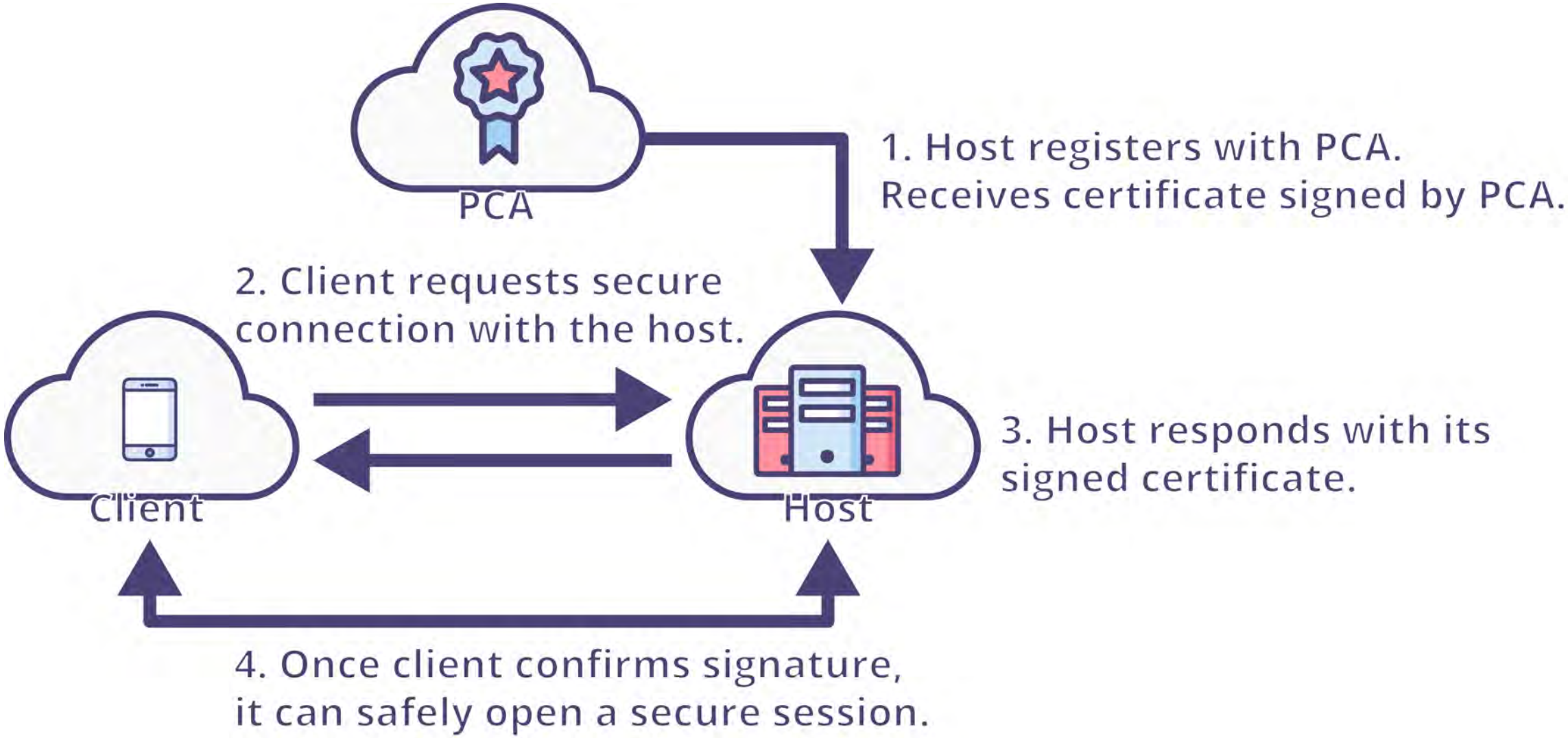
What is a Security Certificate?



What is a Security Certificate?

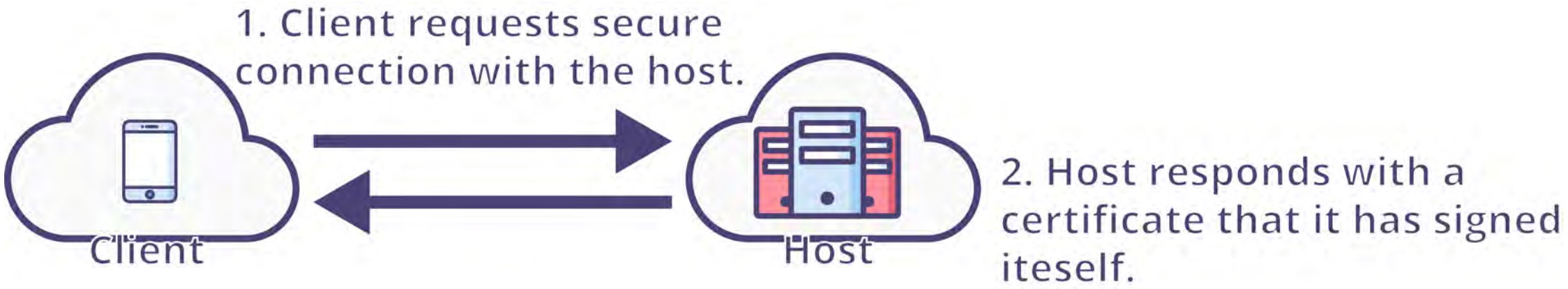


What is a Security Certificate?

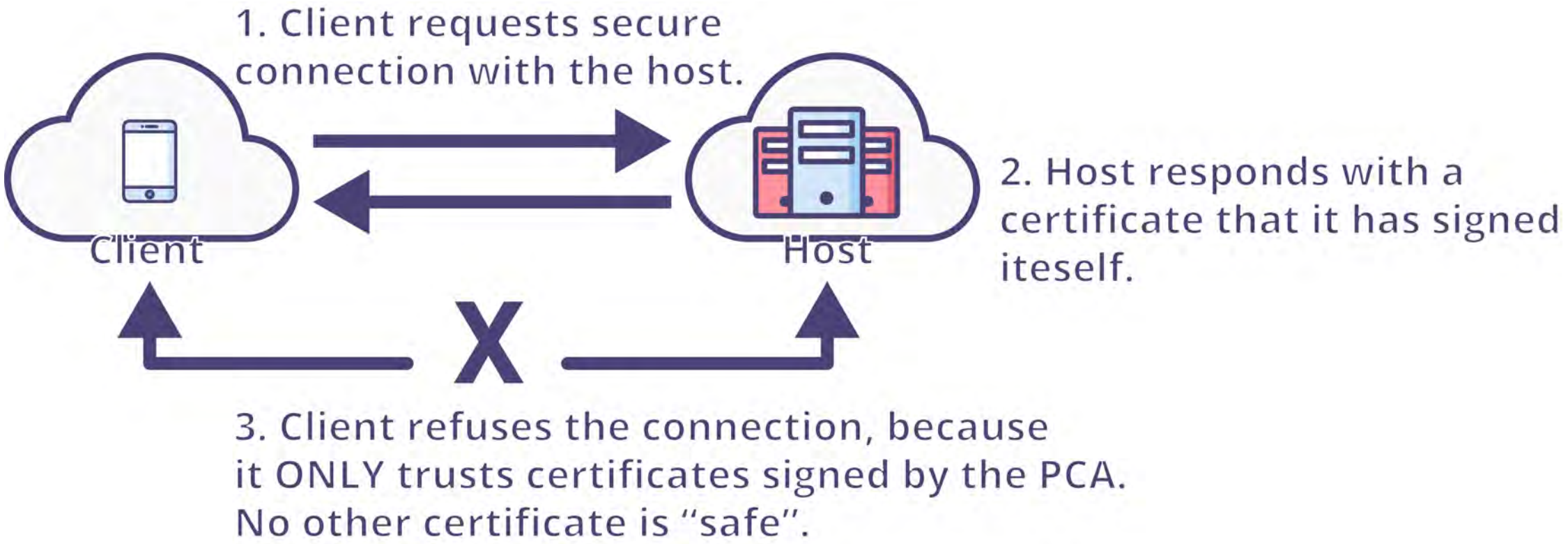


Self-Signed Certificate (NOT allowed)

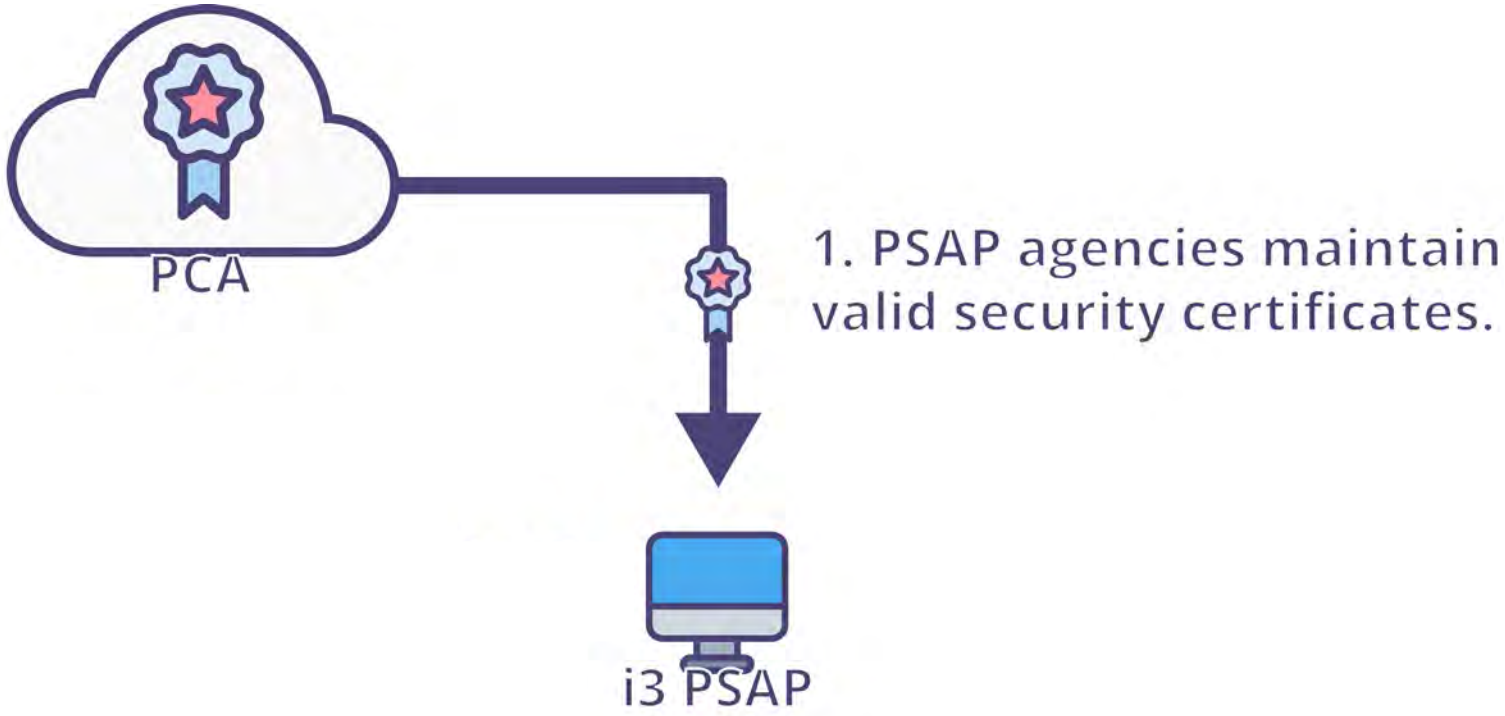
Self-Signed Certificate (NOT allowed)



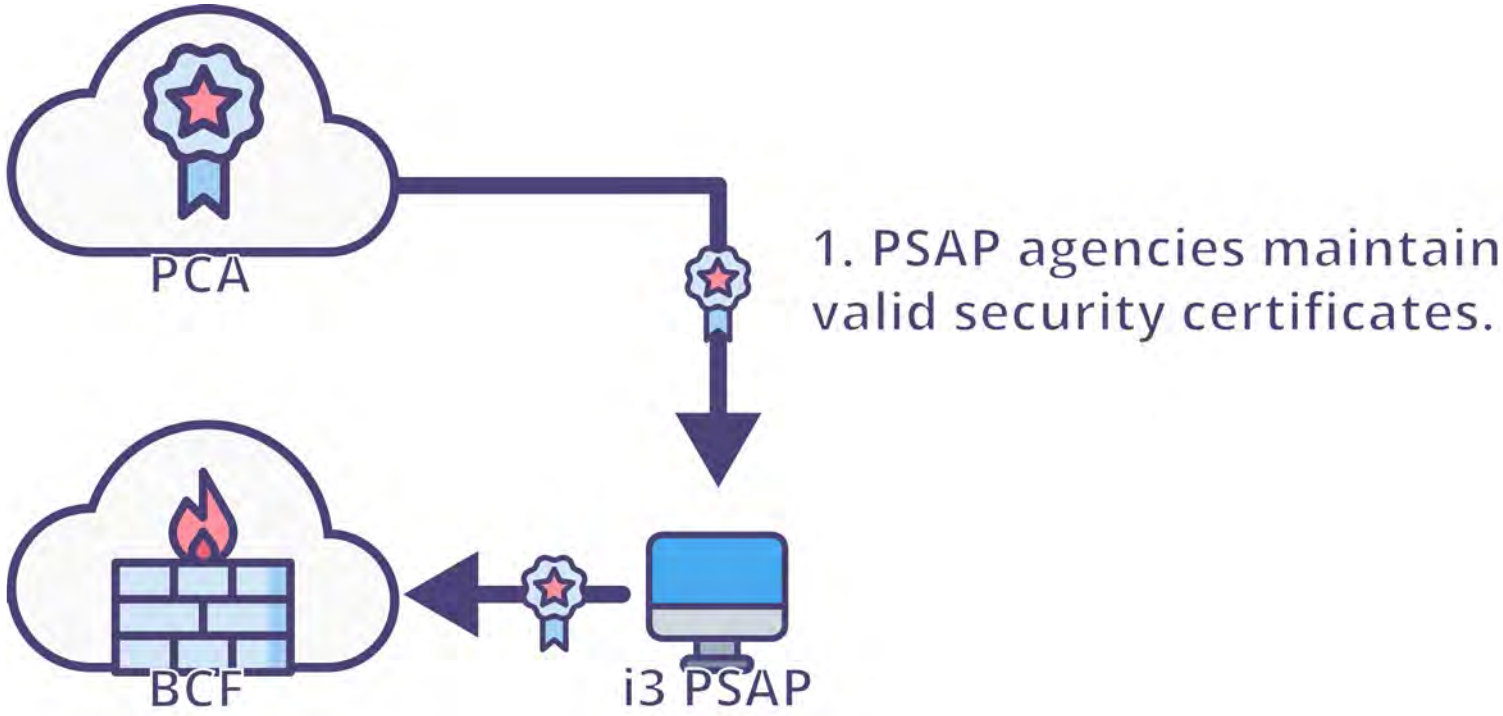
Self-Signed Certificate (NOT allowed)



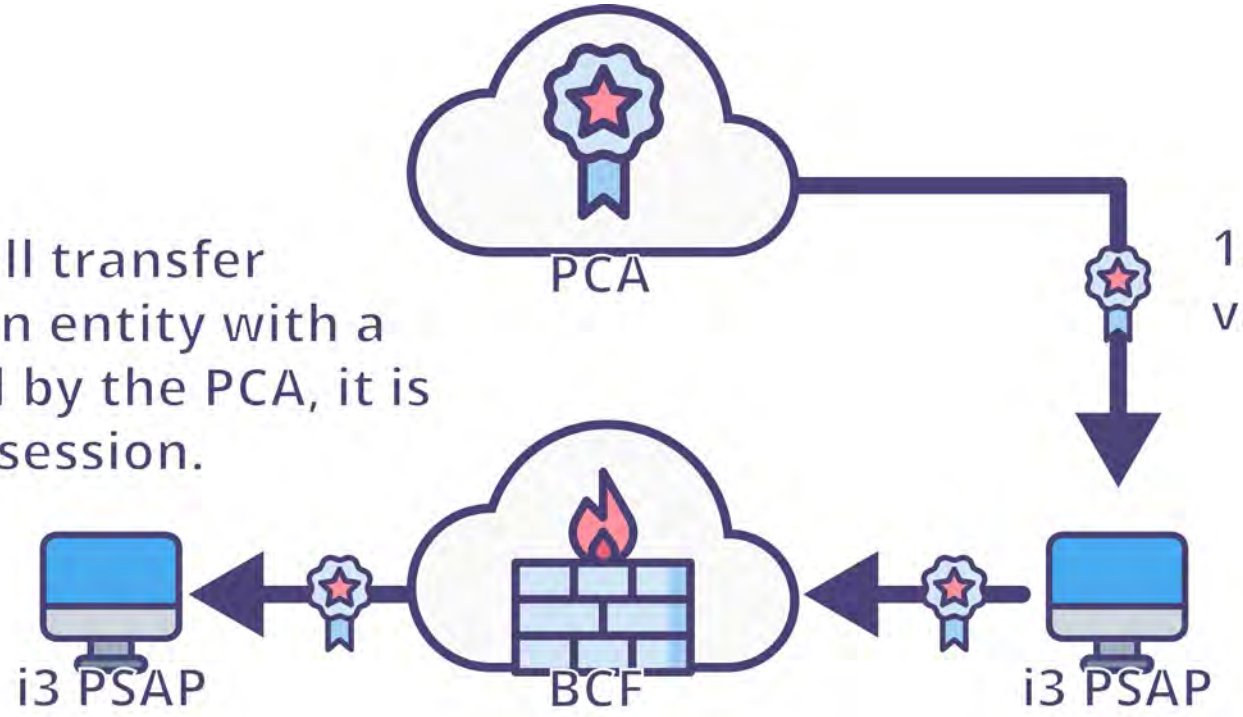
Call Transfer with PCA



Call Transfer with PCA



Call Transfer with PCA



1. PSAP agencies maintain valid security certificates.

2. Call is transfered to another PSAP via the NG9-1-1 system.

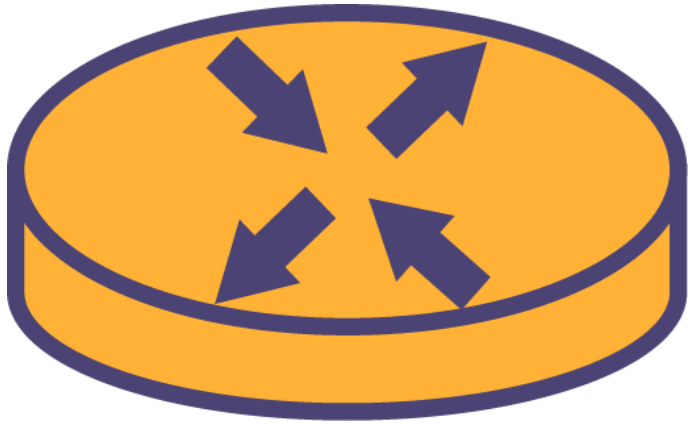
3. Because the call transfer request is from an entity with a certificate signed by the PCA, it is safe to initiate a session.

PCA and Credentialing

- PCA provides for a **root of trust** for NG9-1-1 so that elements and systems can trust each other
- **BY DESIGN,** PCA is conventional third-party certificate authority; other than that it is specific for public safety and some guidelines on specific roles and responsibilities, there is not much unique to it technically
- PCA is **REQUIRED** for many interactions in i3; therefore, without a PCA, there is no ability to comply with i3
- NENA is currently in plans to develop and implement the PCA

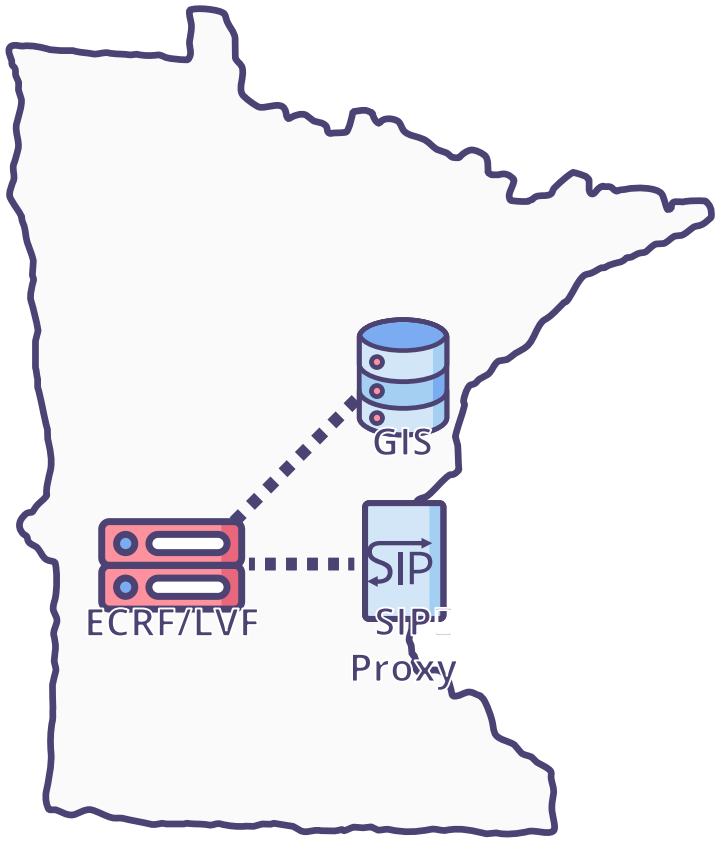
The Forest Guide

- **Required** functional element
- IETF RFC: 6739 and NENA i3 version 3 (pending)
- Top-level listing of NG9-1-1 systems
  - Includes boundary and address for each system
  - 100-200 such anticipated boundaries
- Provides lookup for each NG9-1-1 system
  - Query Forest Guide with a location
  - Forest Guide returns SIP address for BCF
- NENA plans to begin implementing a Forest Guide by end of 2019



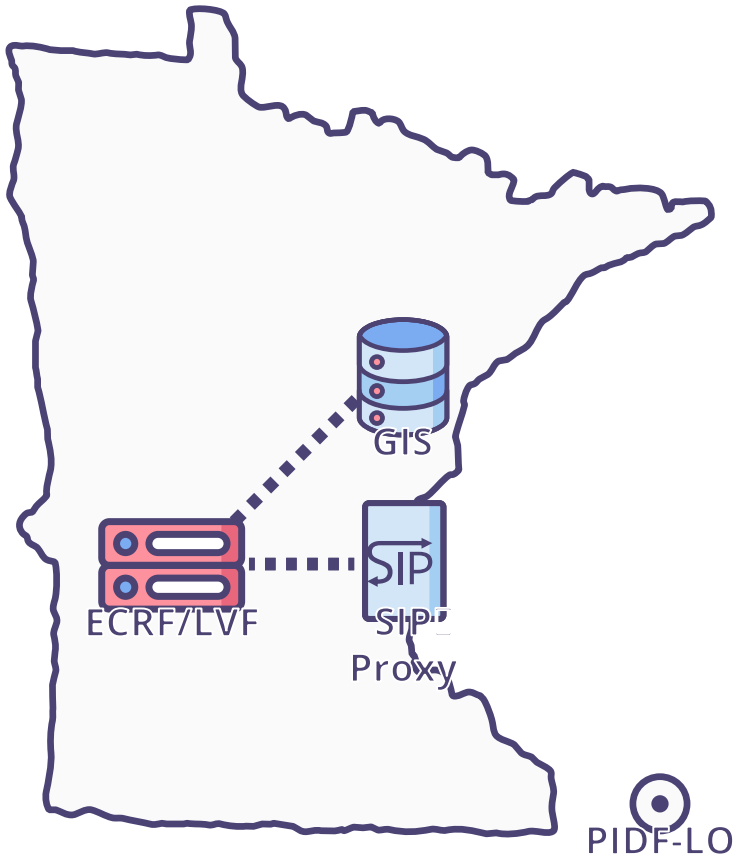
Example: Call Transfer

- In this example, we will look at Minnesota, who is operating a statewide NG9-1-1 System.



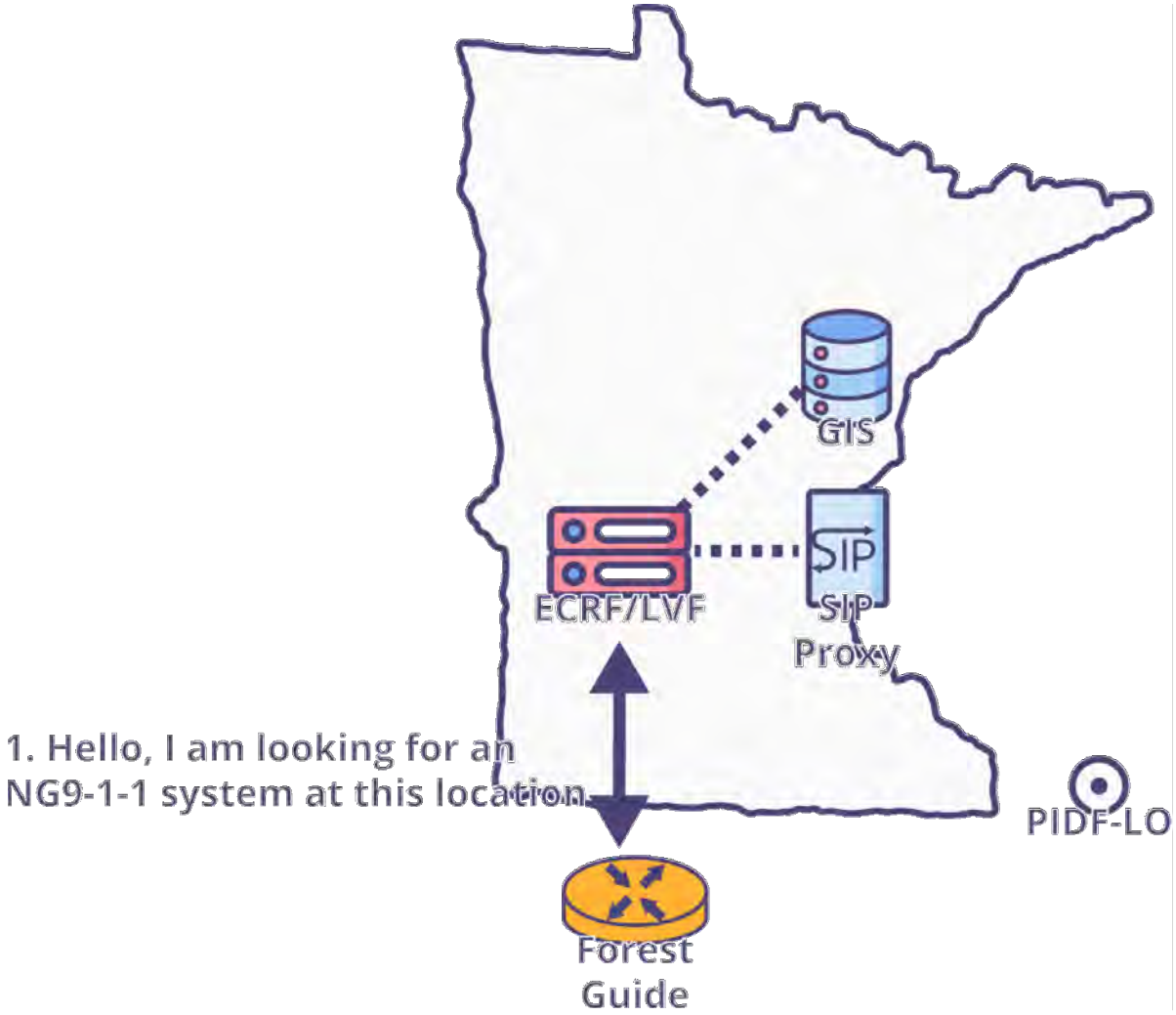
Example: Call Transfer

- In this example, we will look at Minnesota, who is operating a statewide NG9-1-1 System.
- A call is received by the system. However, after querying the ECRF, the SIP Proxy determines it has no routable address for the call.



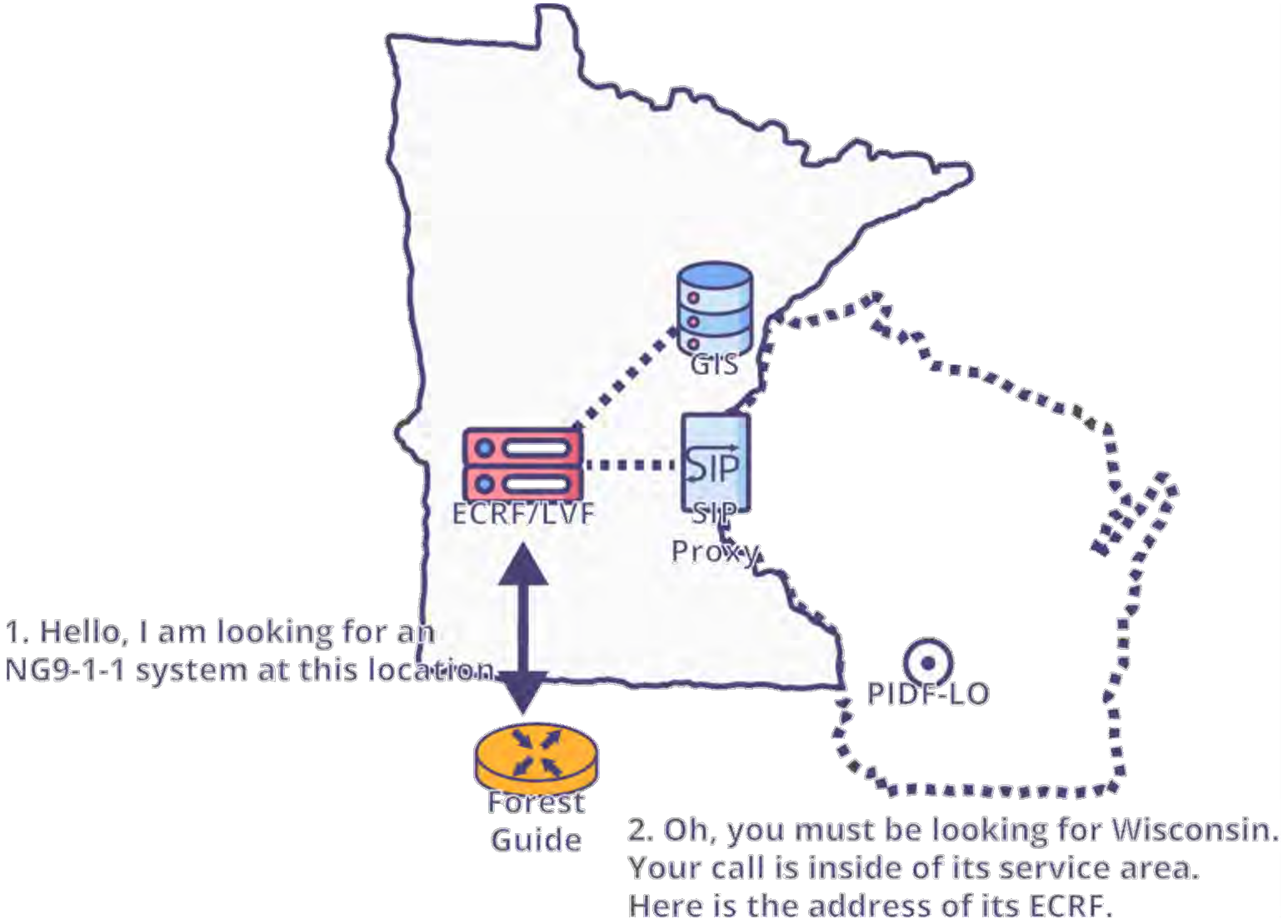
Example: Call Transfer

- In this example, we will look at Minnesota, who is operating a statewide NG9-1-1 System.
- A call is received by the system. However, after querying the ECRF, the SIP Proxy determines it has no routable address for the call.
- The Forest Guide contains routing information for every NG9-1-1 system in the United States. The Proxy asks for help.



Example: Call Transfer

- In this example, we will look at Minnesota, who is operating a statewide NG9-1-1 System.
- A call is received by the system. However, after querying the ECRF, the SIP Proxy determines it has no routable address for the call.
- The Forest Guide contains routing information for every NG9-1-1 system in the United States. The Proxy asks for help.
- The Forest Guide is aware that location is served by a statewide NG9-1-1 system in Wisconsin.

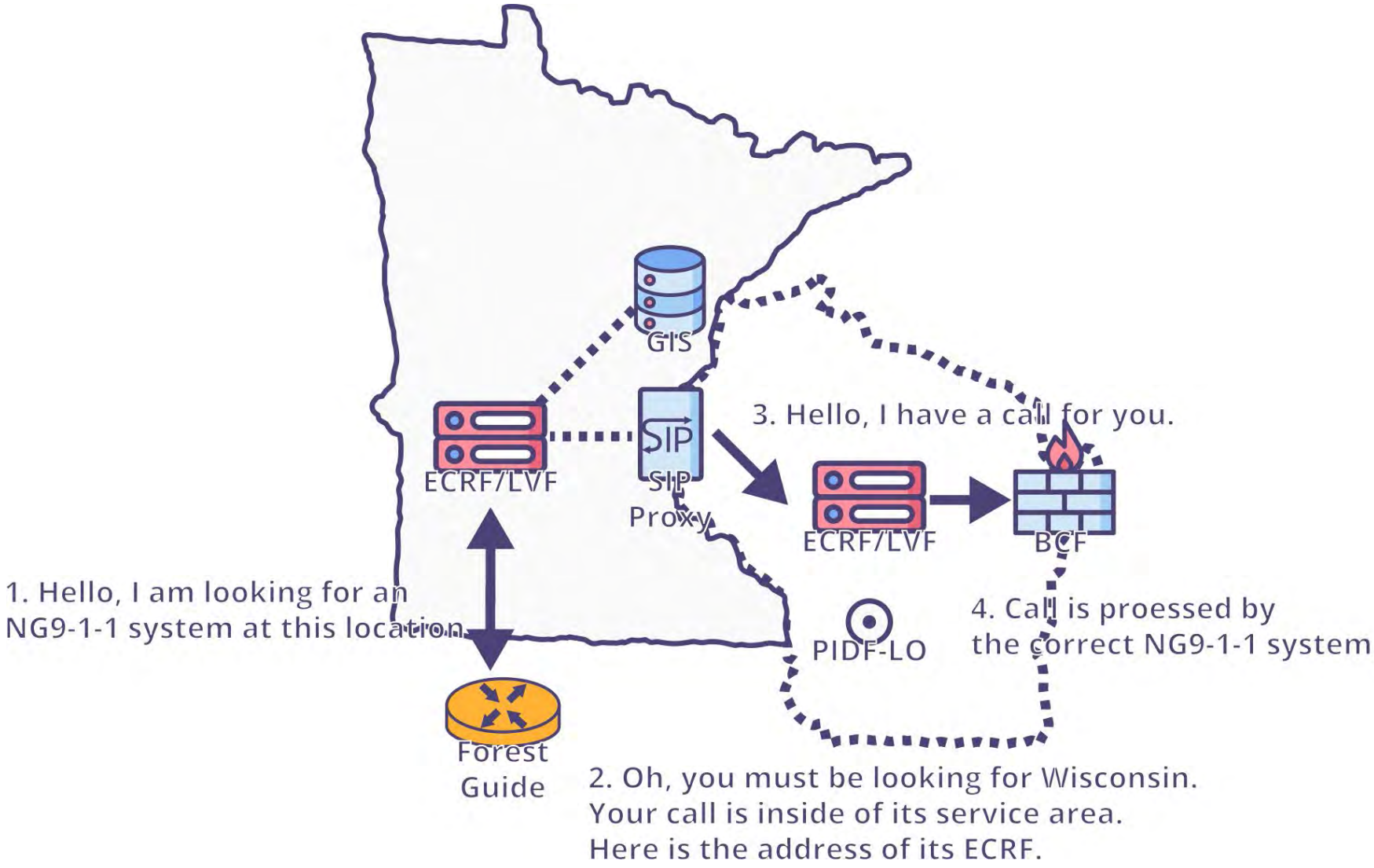


Example: Call Transfer

- The Proxy now initiates a session via the correct ECRF.

Example: Call Transfer

- The Proxy now initiates a session via the correct ECRF.
- Wisconsin's NG9-1-1 system accepts the call
- The call is processed within Wisconsin's NG9-1-1 system normally and the session initiated with the caller.

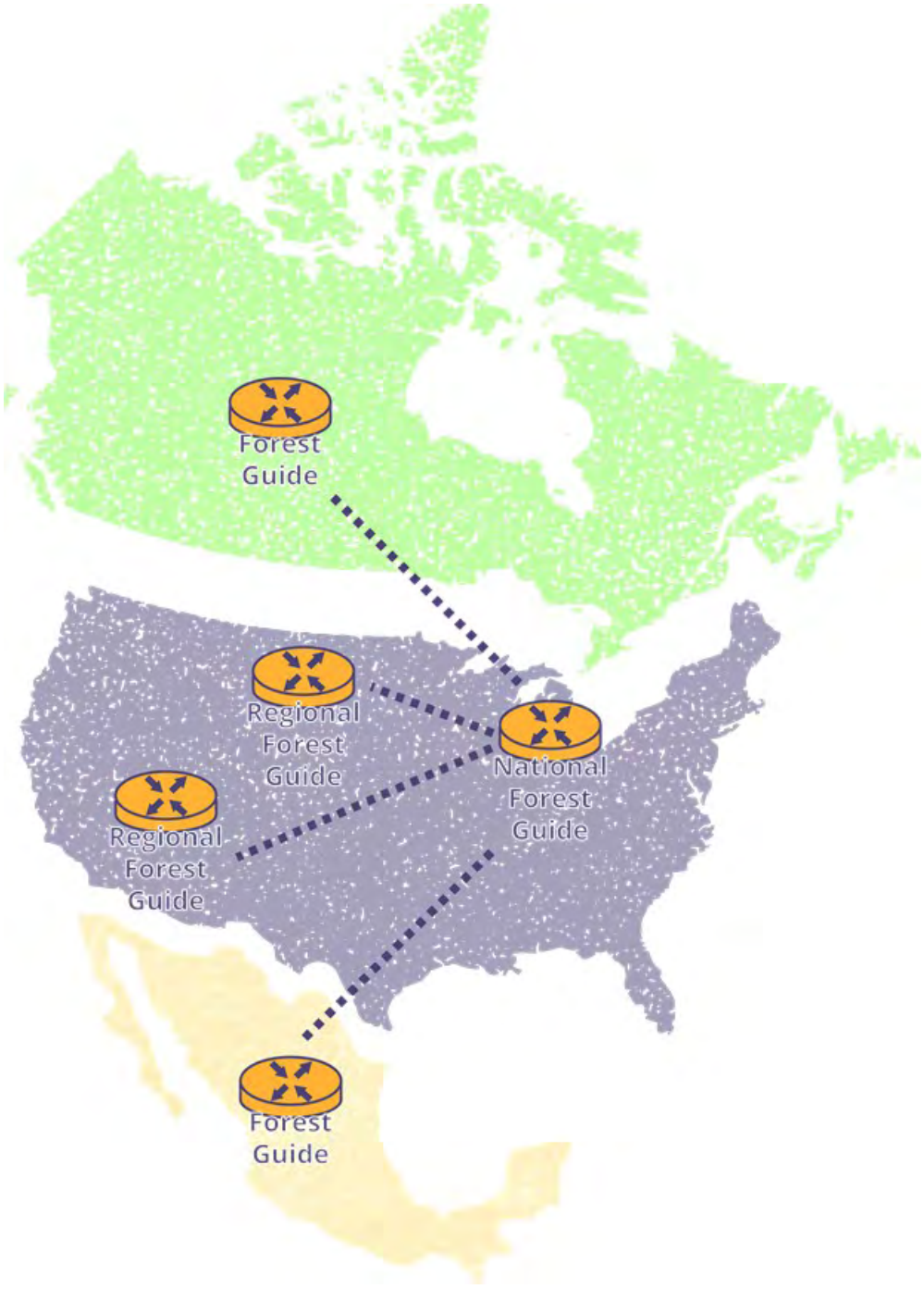


Call Transfer

- Not every NG9-1-1 system will be statewide
- The Forest Guide will index NG9-1-1 systems **and** other Forest Guides
- Some NG9-1-1 systems **may** be configured to transfer calls directly, depending on local policies and relationships
- The Forest Guide **may** answer queries for entities other than a BCF
- If Forest Guide says, “no NG9-1-1 system here”, PSAP can use legacy call transfer mechanism

International Context

- NENA Model: each nation or group of friendly nations to have one top-level Forest Guide
- Top-level forest guides **may** contain routing information for regional/child Forest Guides
- Since Forest Guides are defined in IETF standards, and i3 is enjoying international adoption, most nations should be compliant



Forest Guide: Closing

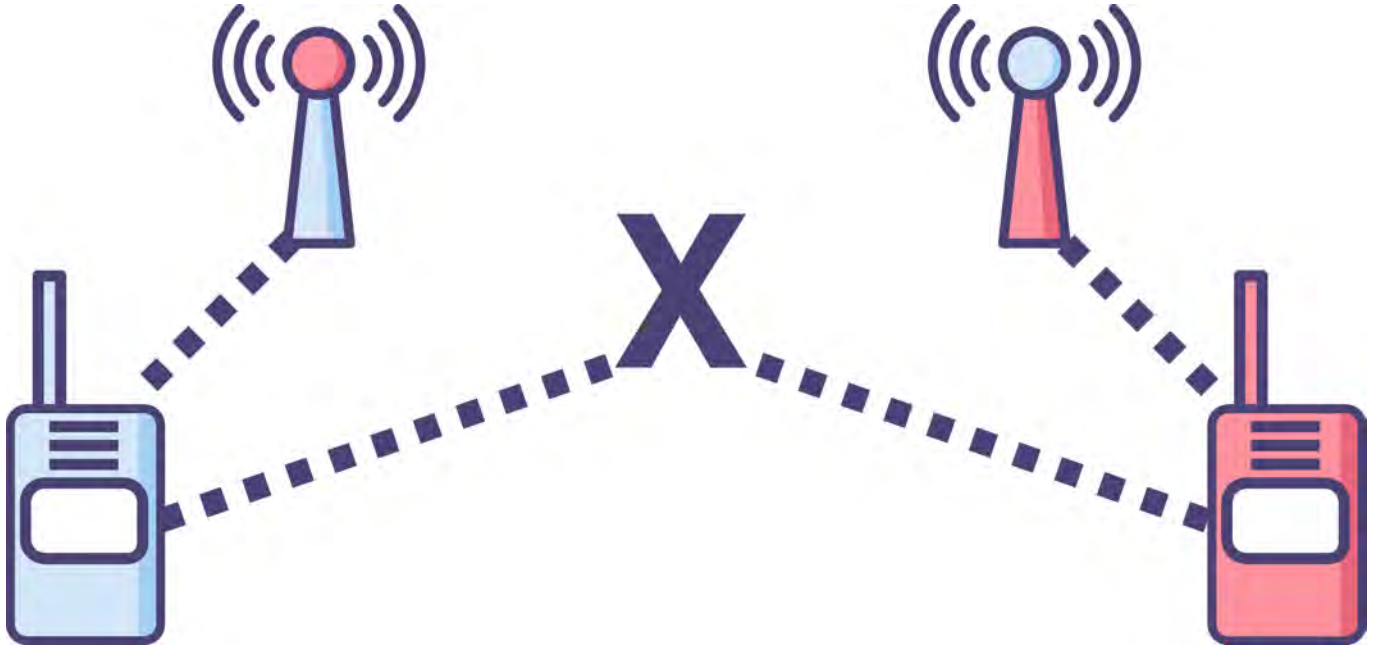
- While NG9-1-1 systems can be configured with routing information for neighbors, in not all scenarios will a network element be preconfigured to discover the NG9-1-1 system it needs to interconnect with
- The Forest Guide provides for discovery and interoperability for NG9-1-1
- The Forest Guide is NOT intended to be the default entity to directly query for routing information; it is intended only for interoperability and initial discovery

Providing for Interoperability

- Interoperability in NG9-1-1 is *provided* for through:
  - Standardization of interfaces
  - Conformance and Interoperability Testing
  - Discovery and Security Mechanisms
  - Human, business and policy management
  - Communication and sharing
- Deploying interoperable systems *does not* ensure interoperability
- Generally, interoperability is **not a difficult technical problem**

Example: P25

- Multiple jurisdictions use the same radio technology and vendor
- However, they do not share talkgroup and system information
- There is no technical barrier here; it is entirely policy

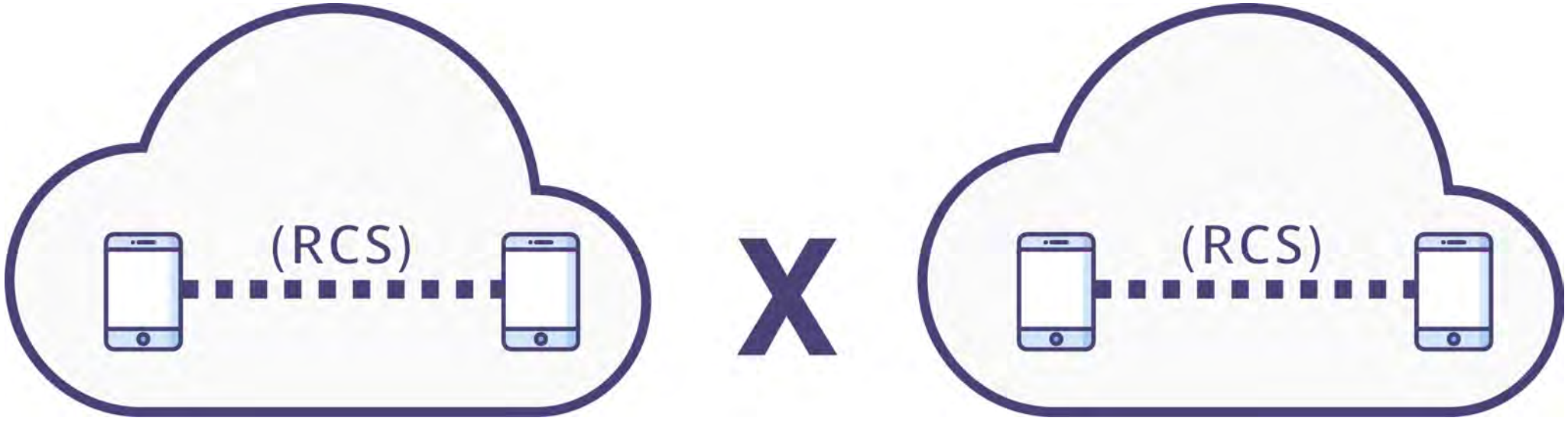


Example: VoLTE, HD Voice (IMS)

- Generally, cellular and VoIP providers use compatible systems for high-fidelity voice based on SIP and with compatible codecs (e.g., G722, G722.2)
- But . . . Limited interoperability between carriers (not a technical issue)

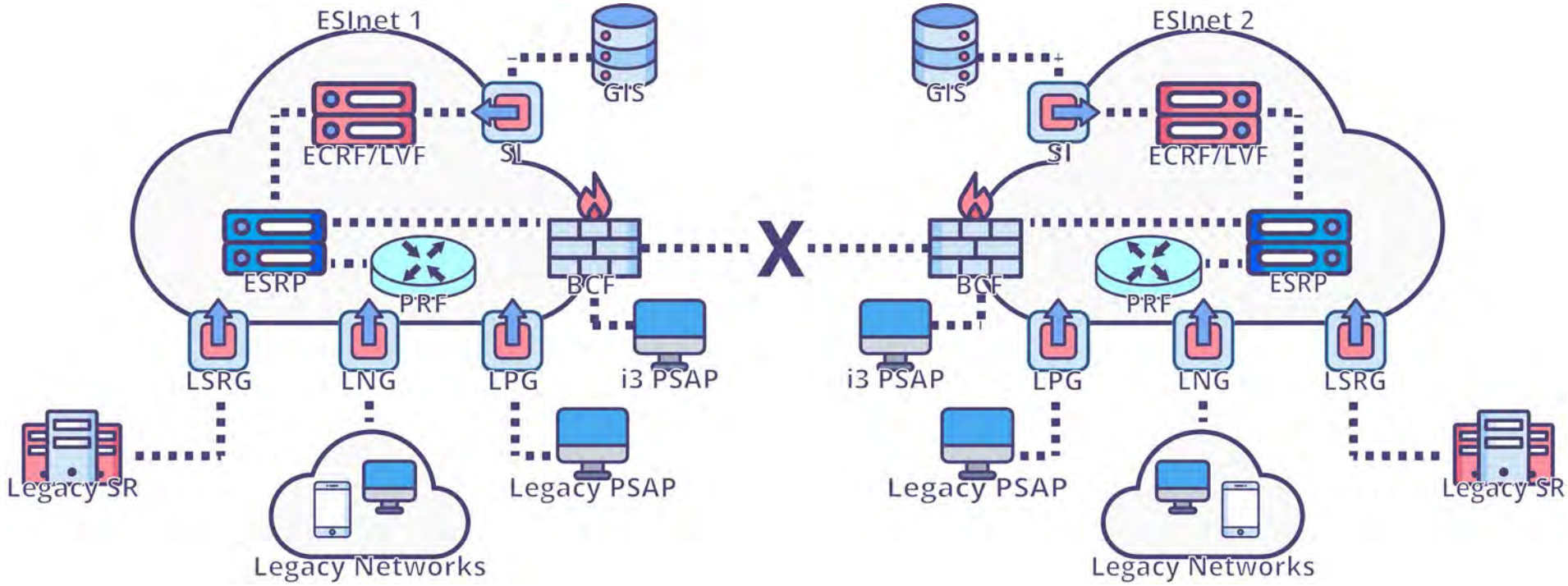
Example: RCS

- RCS (Rich Communications Services) standardizes multimedia messaging; essentially, standardizing features you see in WhatsApp or iMessages
- . . . however, no real inter-carrier interoperability today (not a technical issue)



Example: Transitional NG9-1-1

- Existing deployments of i3-based NG9-1-1 are (theoretically) interoperable
- . . . But with no testing, inter-agency planning or discovery/trust mechanism, deployments do not enjoy inter-system interoperability today (2019)

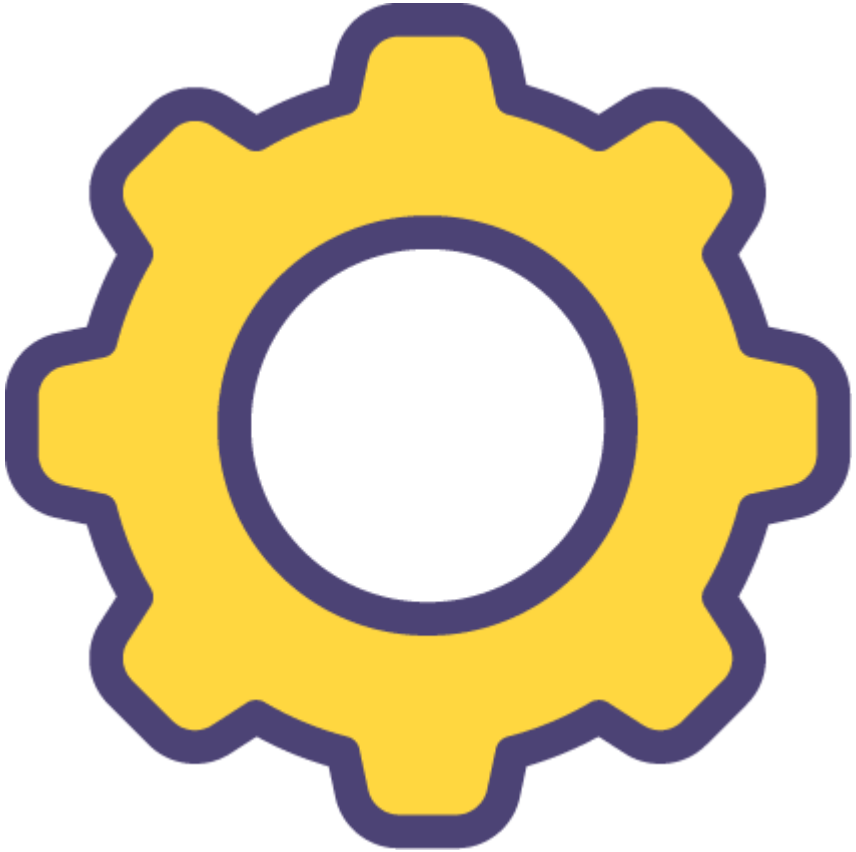


Standards Facilitate Interoperability

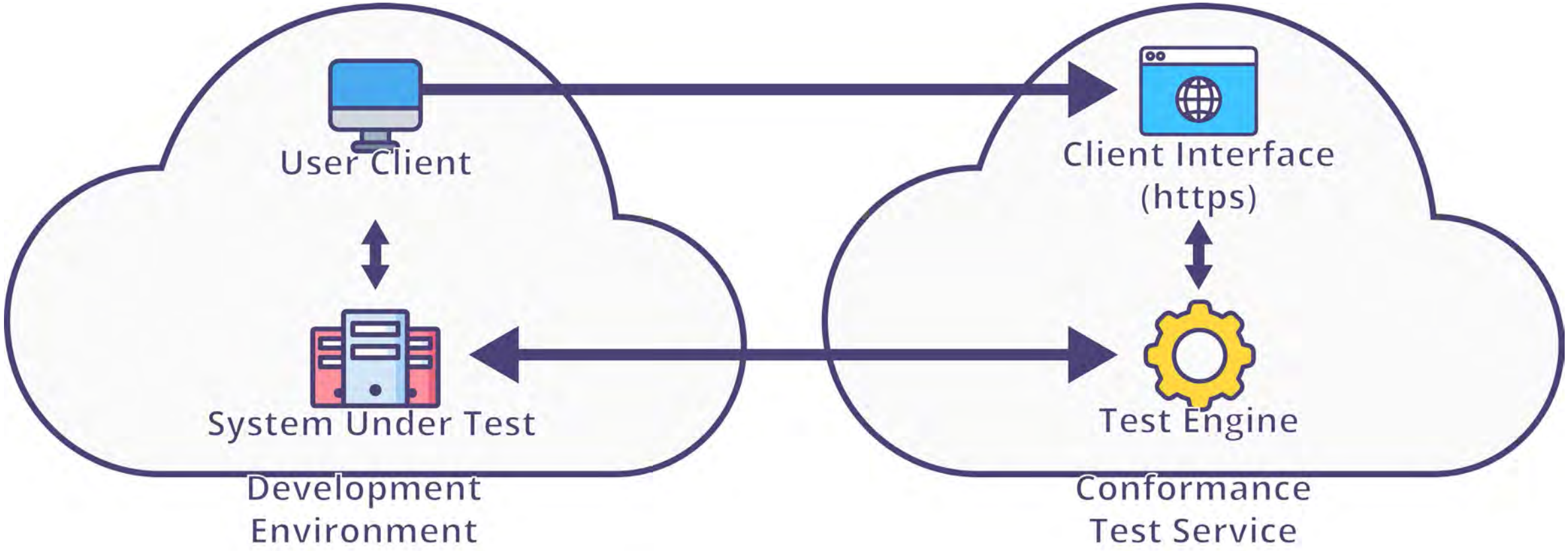
- These examples (should) demonstrate that standards and technology facilitate interoperability between systems
- They should also demonstrate that interoperability is often a policy problem, and not a technical one
- Do not look to standards alone (like i3) to solve your interoperability problems

Conformance Testing

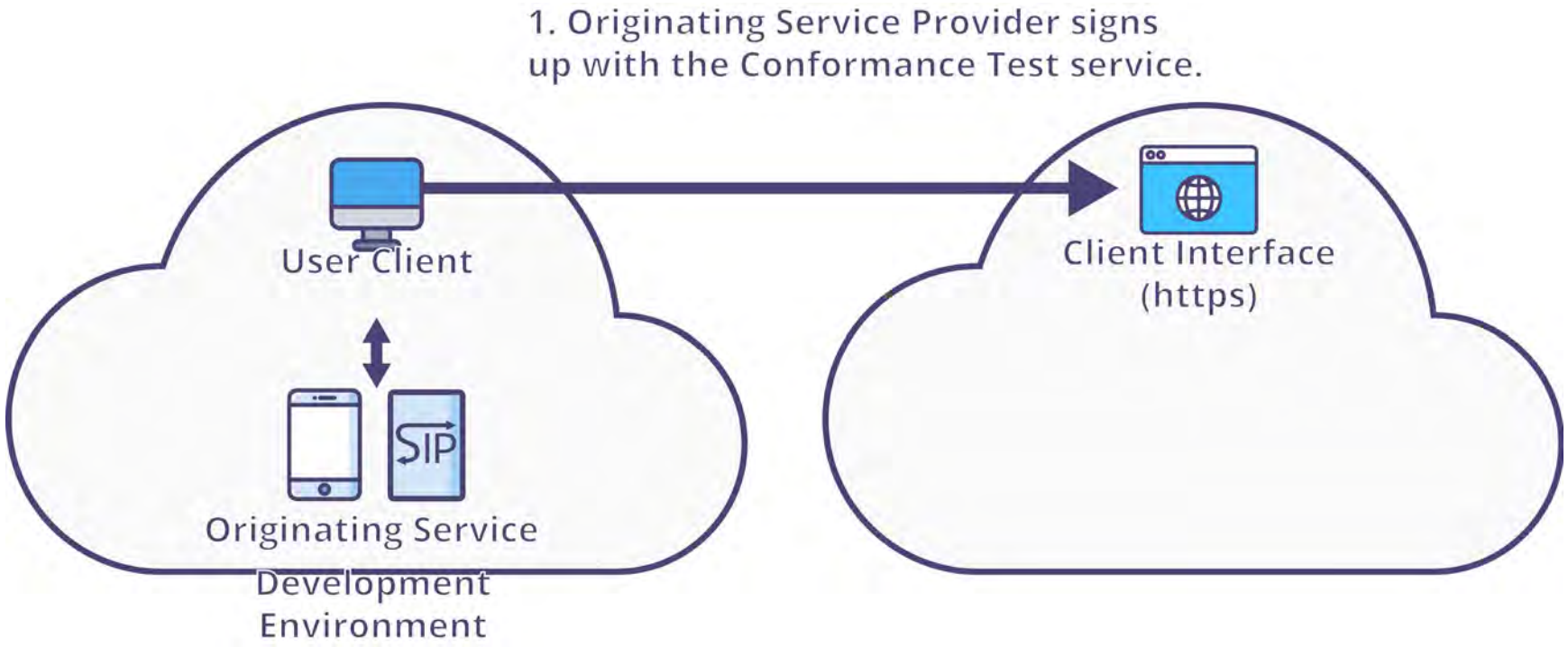
- A standardized platform for testing conformance to standards
- Developed in concert with NG1-1-2 (Europe) test to ensure universal conformance
- Provided as a service to vendors in mid-development
- NENA and industry partners plan to begin implementing by end of 2019



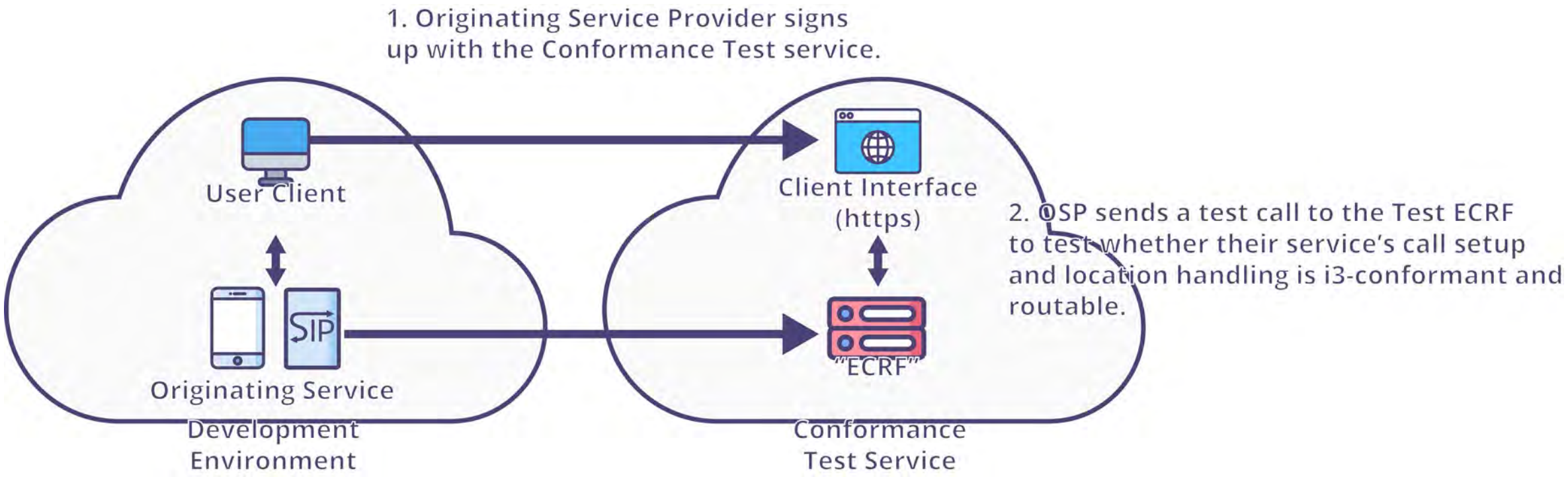
How Conformance Testing (may) Work



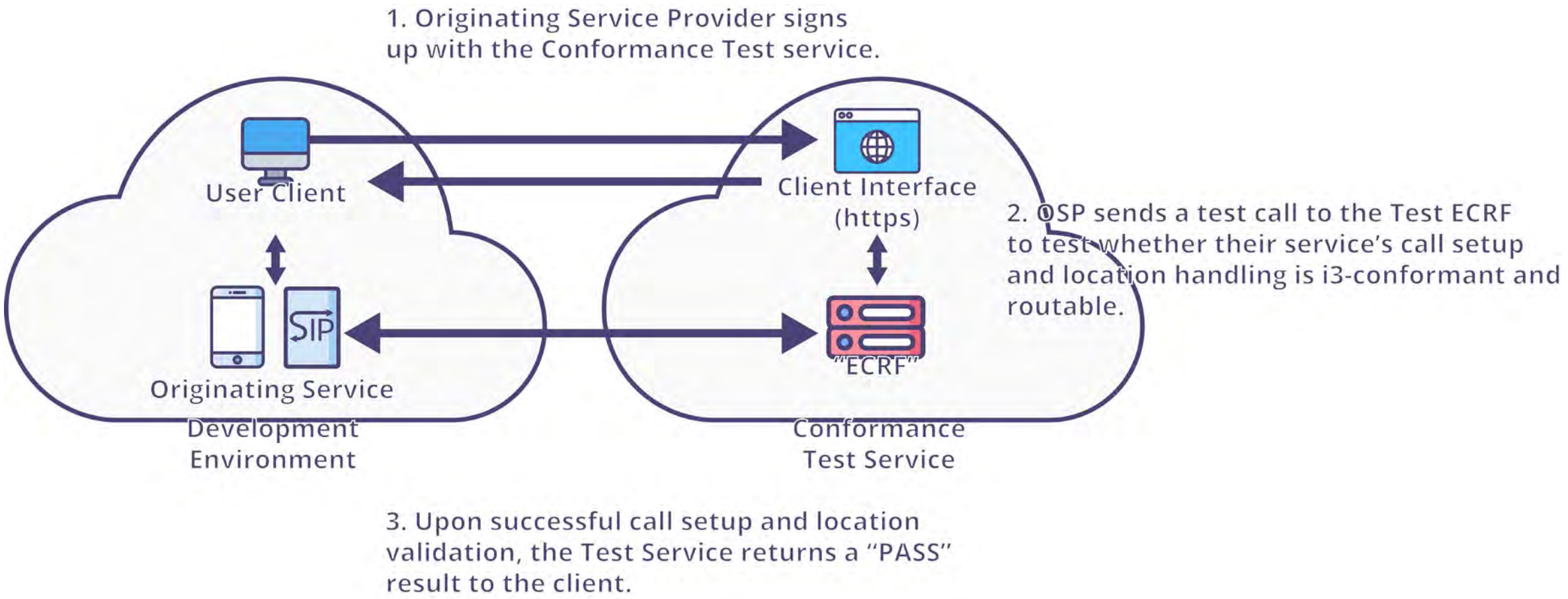
Practical Example: Location Test



Practical Example: Location Test



Practical Example: Location Test

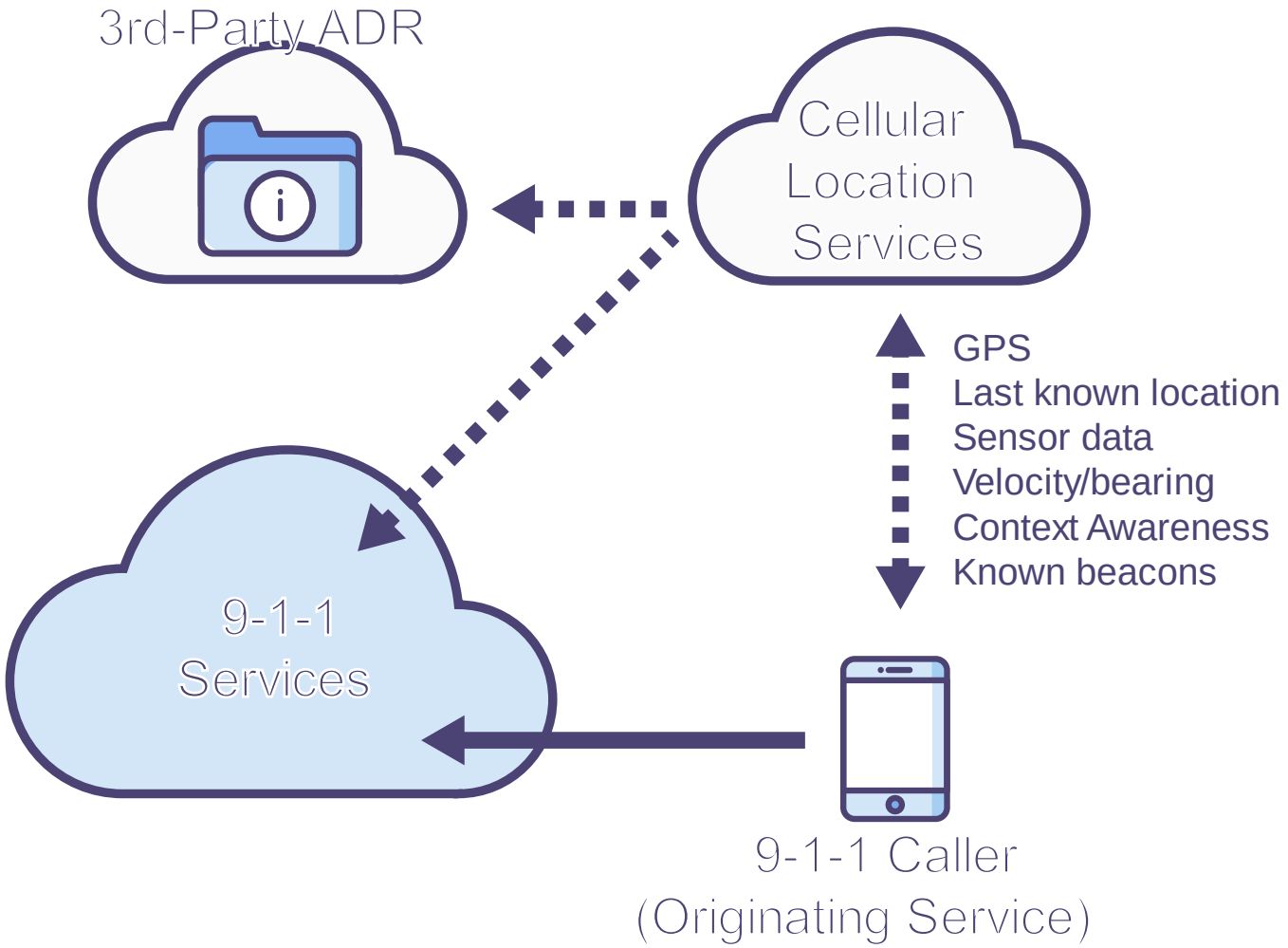


Conformance Testing Objectives

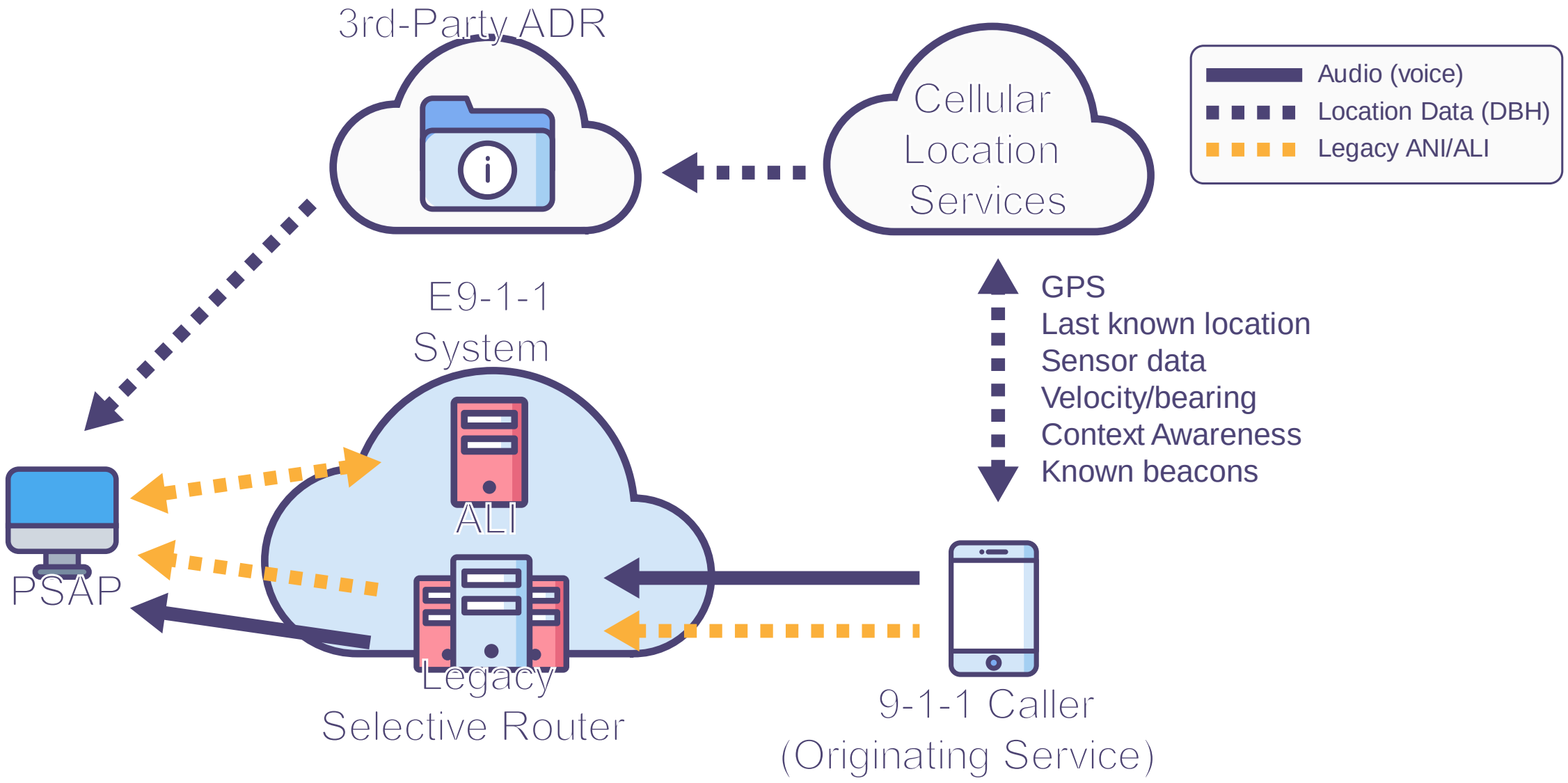
- Reasonable barrier to entry: system must be available for major enterprises as well as for small start-ups
- Industry participation: develop a conformance testing environment that is supported by industry partners who will be compelled to use it
- Standardization: develop a conformance testing environment that ensures a high degree of standards conformance through a comprehensive testing environment that is supported by all parties

Emergency Location Services (DBH)

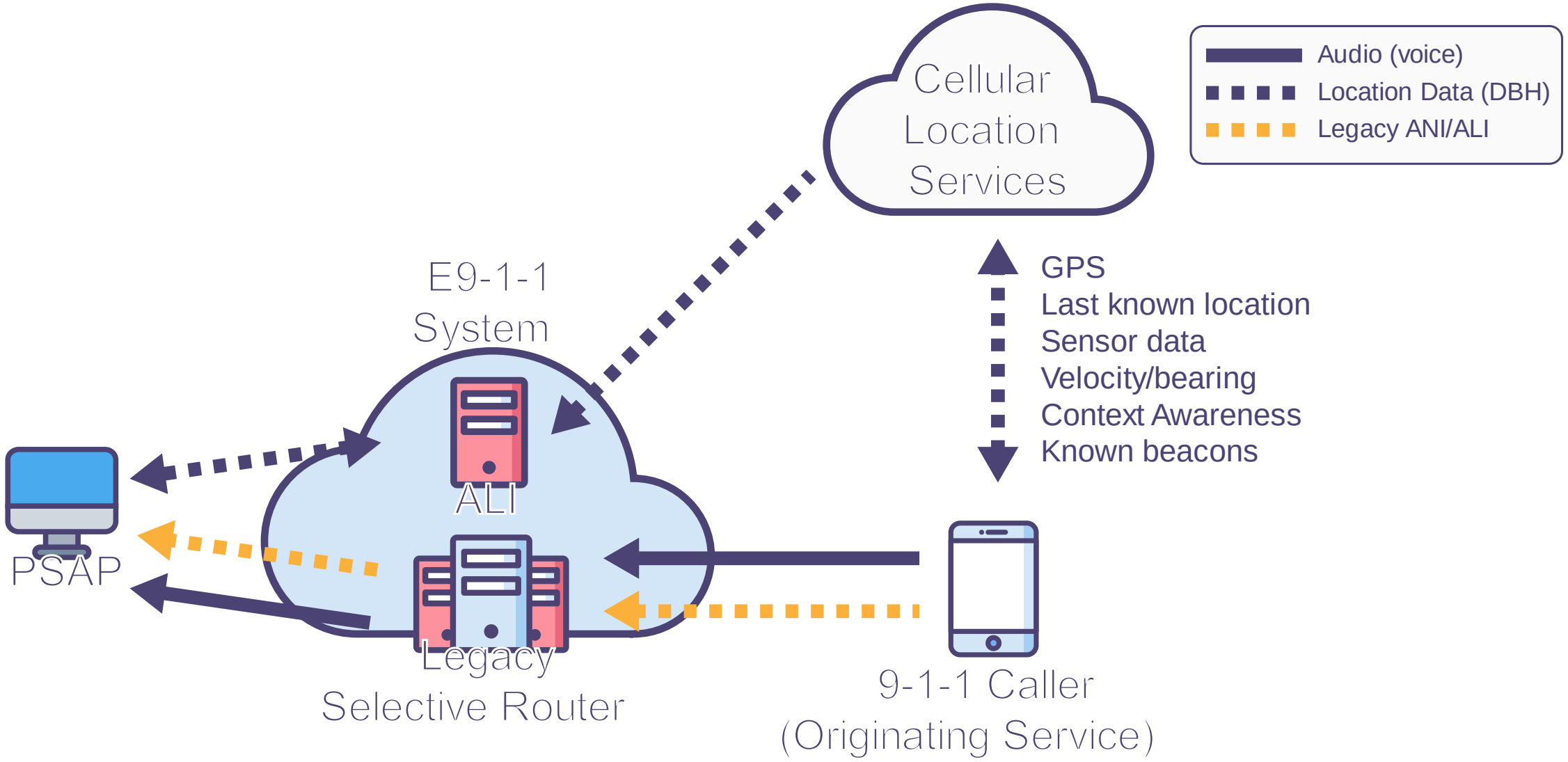
- Google: ELS and Apple: HELO
- Uses location services technology to make caller location available for emergency services
- Designed to be delivered directly into 9-1-1 services
- Also available to third-party services, like Additional Data Repository (ADR) providers



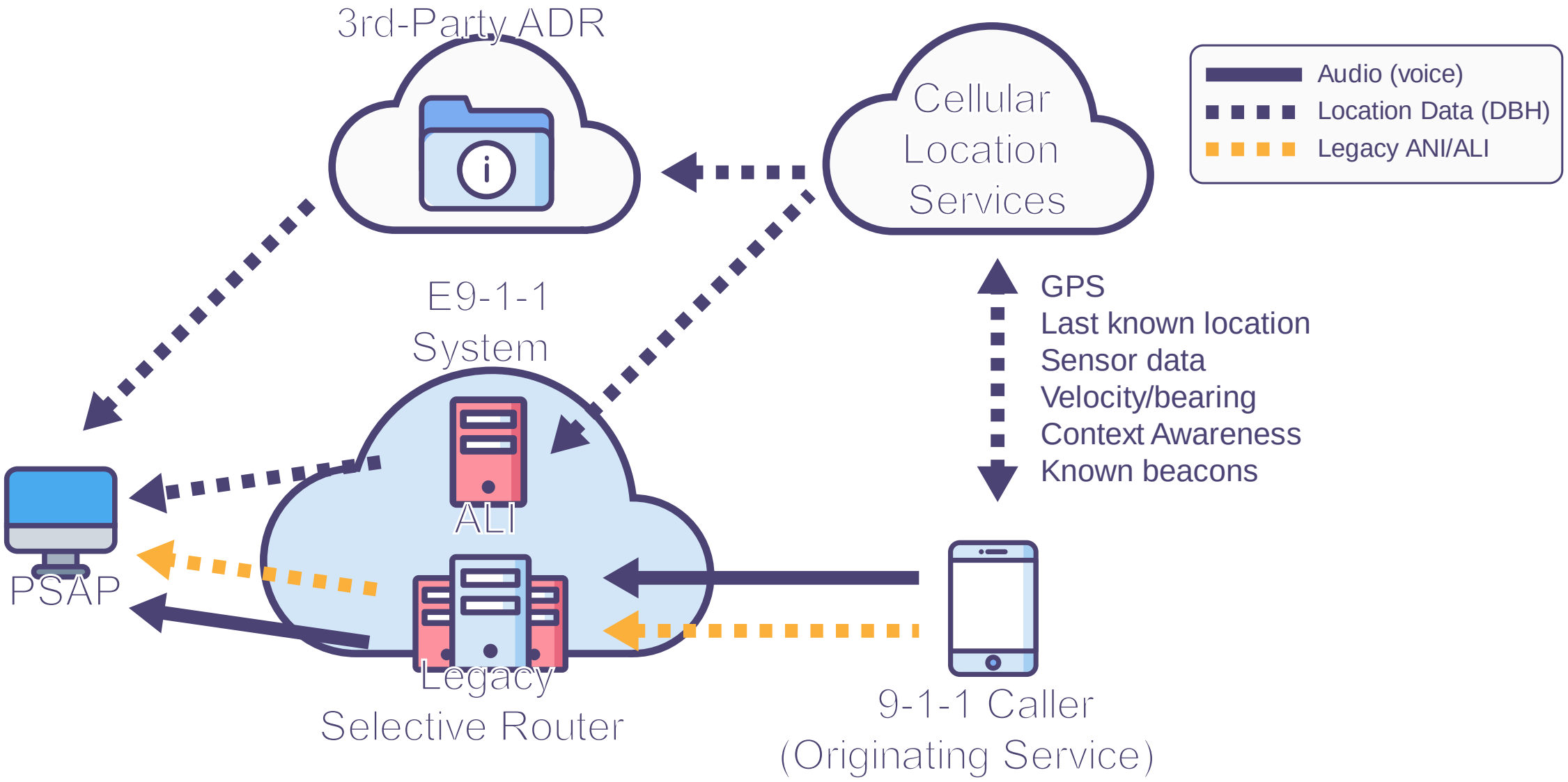
Delivering as Supplemental Location



Injecting DBH into ALI



Same Location from ADR and ALI (!)



Challenges with DBH

- Generally, DBH provides more accurate location than legacy E9-1-1 aGPS
- Relying on DBH as a means of location places a higher reliability on a best-effort service; location services exist outside of SLAs and regulatory regime
- If provided through third-party ADR, DBH is a wholly best-effort service with no guarantee or quality of service
- If provided through carrier services, DBH is subject to regulatory regime including specific benchmarks enforced by FCC
- Same location data, different delivery mechanisms, much different liability

Reverse-Geocoding (Rev-Geo)

- Uses mapping data and location to make a best guess as to your address
- In doing so, discards location information and degree of certainty

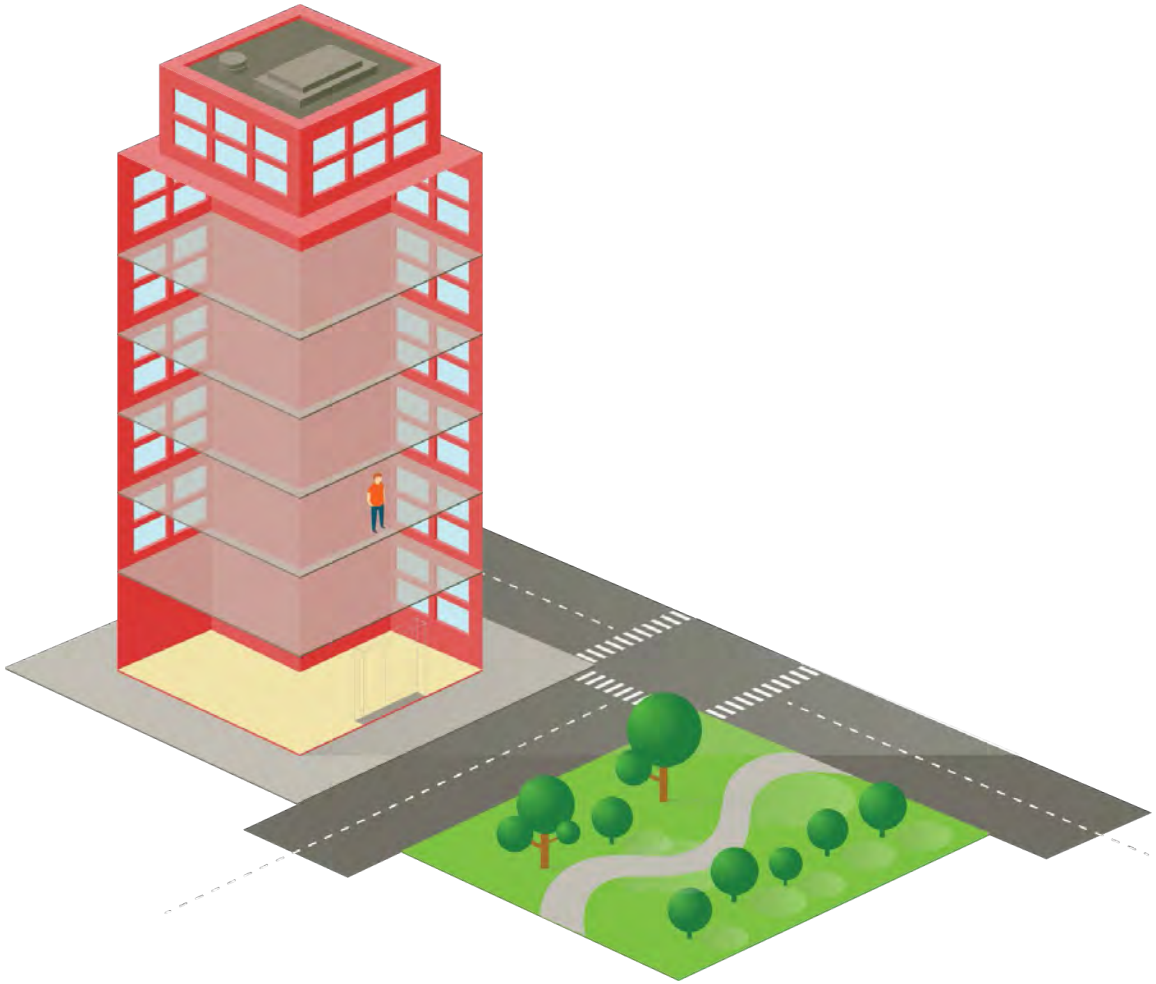
Rev-GEO

- If you **MUST** have an address, Rev-GEO will convert a location to an address
- You will then have an address—no matter what
- The output is only as good as the input
- A poor location will also provide a poor address
- Rev-GEO can provide a false sense of certainty, because it can take bad location and convey a specific address that may be incorrect

Locating a Person

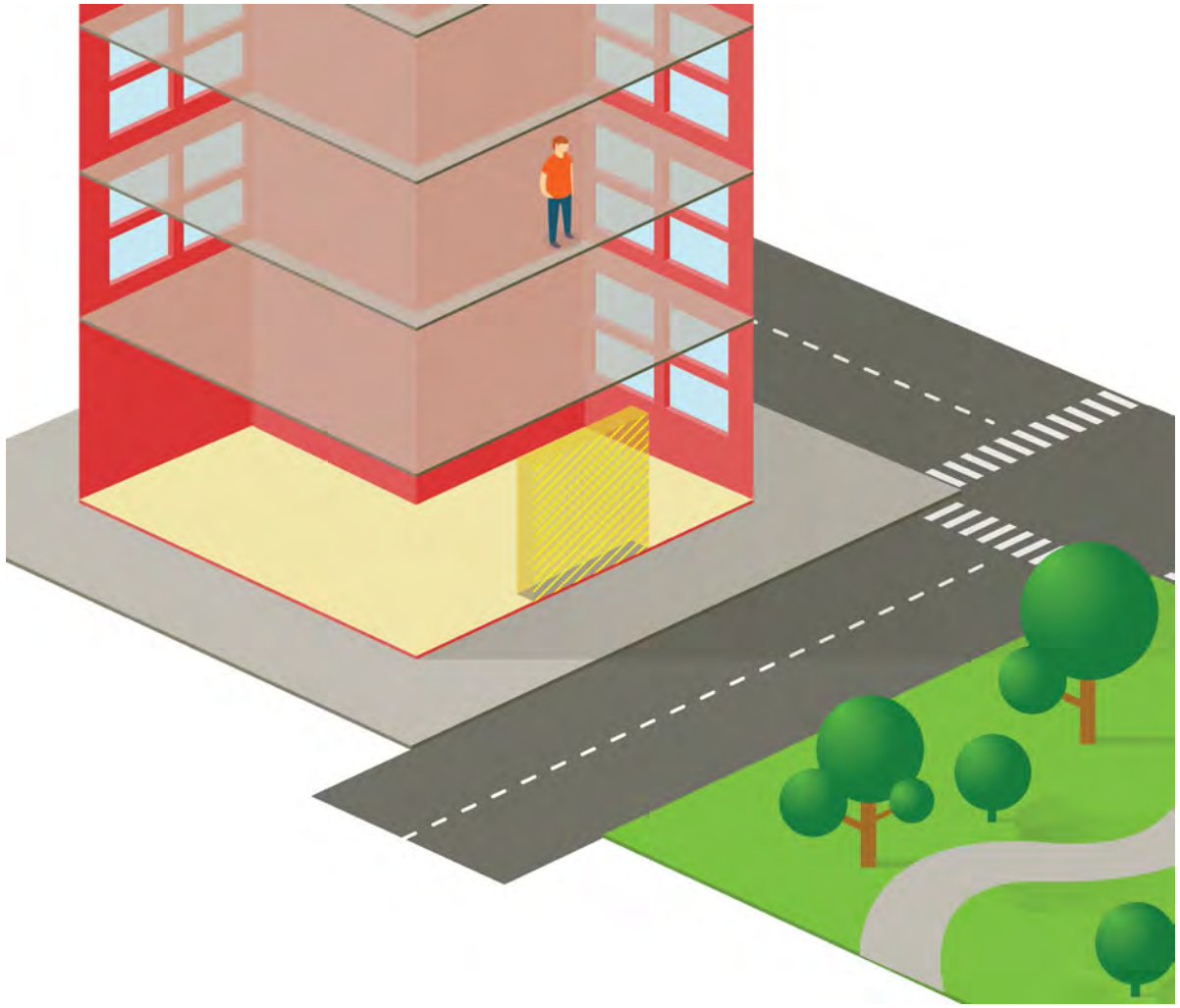
- Most people live and/or work in multi-tenant structures
- One civic Address
- Many floors
- Many suites
- We can’t rely on GPS, but as we just learned, there are other technologies to locate the caller

Locating a Person



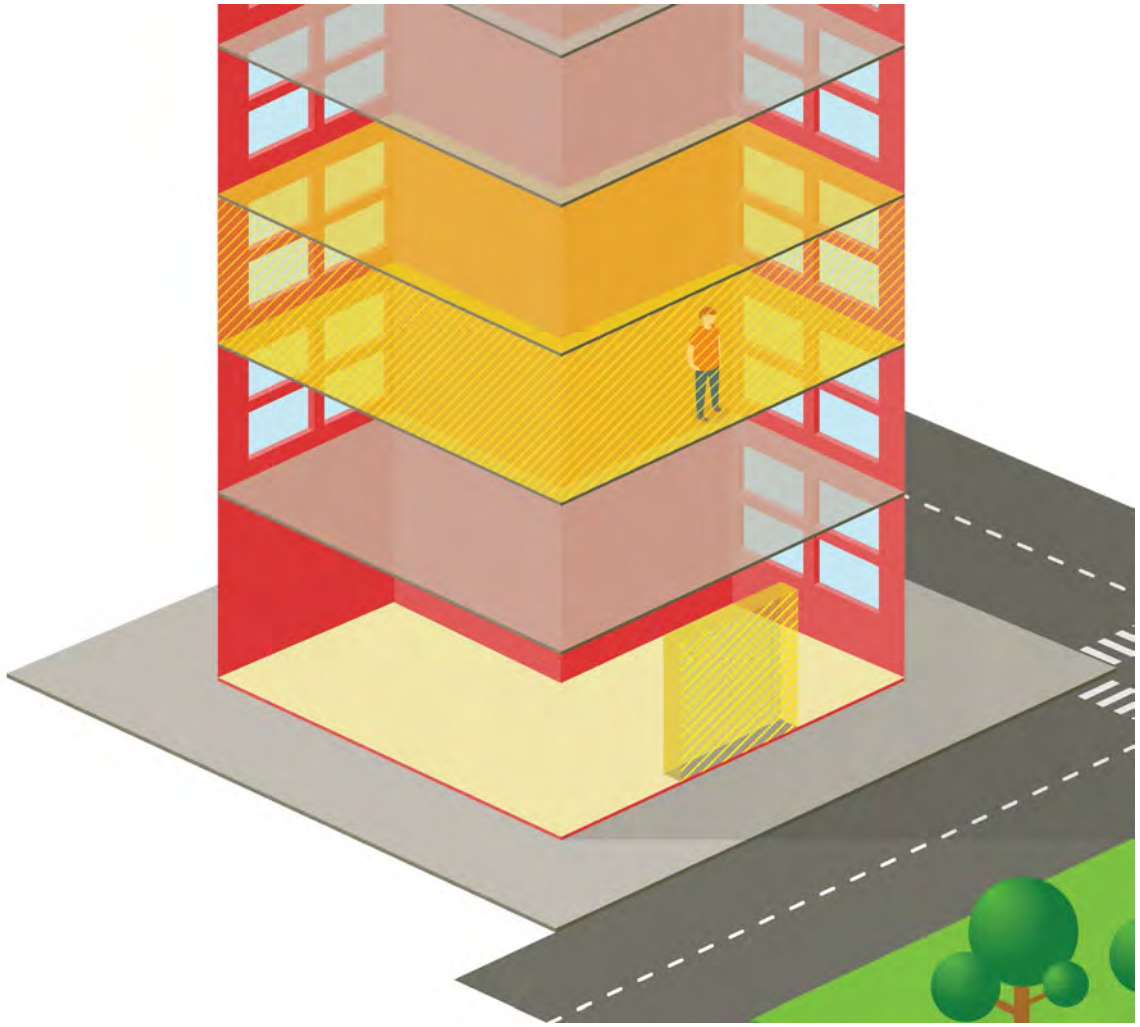
- Caller actual location is 1234 NENA Blvd, Suite 200
- What is a suitable dispatchable location to locate the caller?
- Let's review a few scenarios . . .

Civic Address Only (Reverse-Geocode)



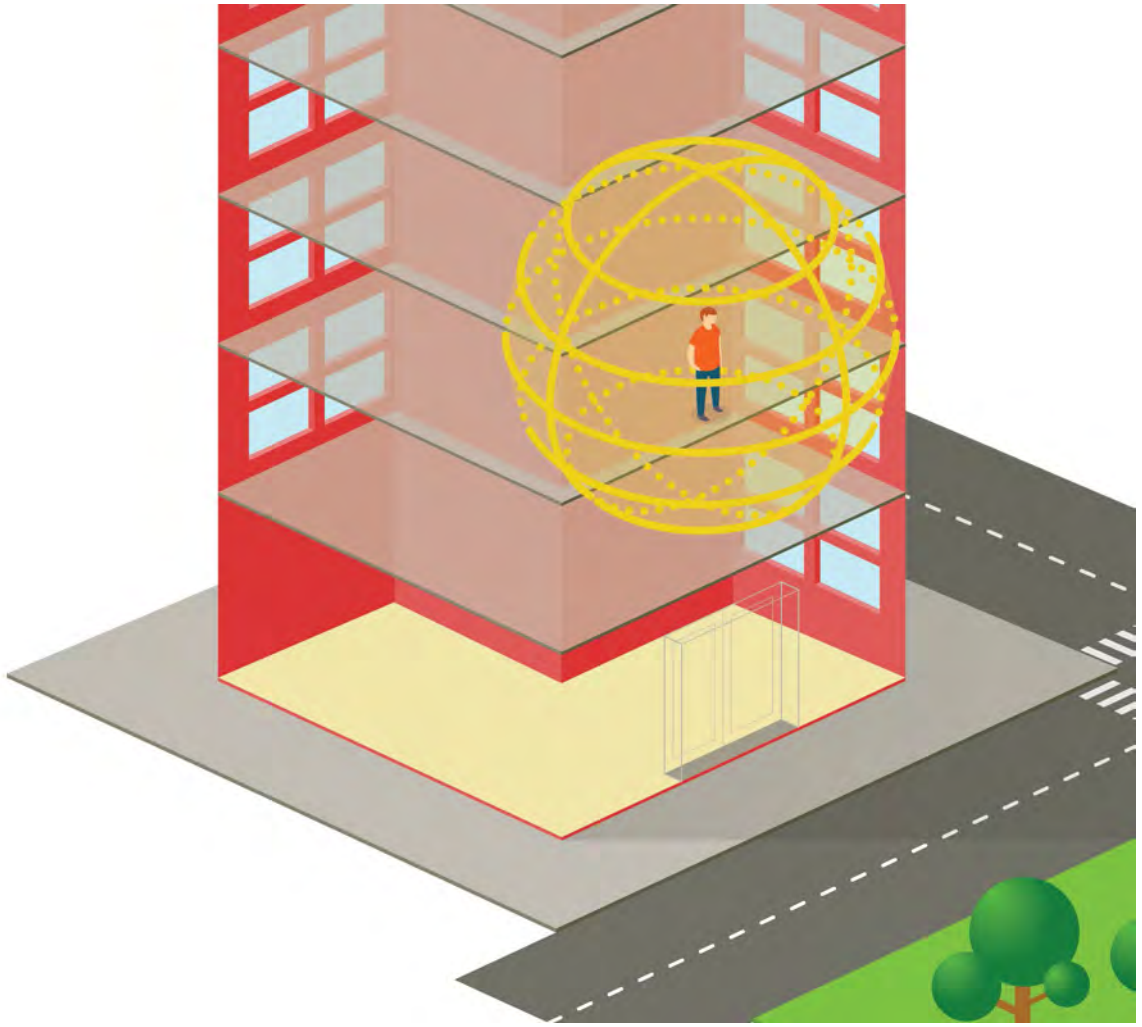
- Civic Address is 1234 NENA Blvd
- No specific location information for the caller
- We have to depend on information from the caller and/or gathered on-scene to locate the caller

Civic Address and Z-Axis Only



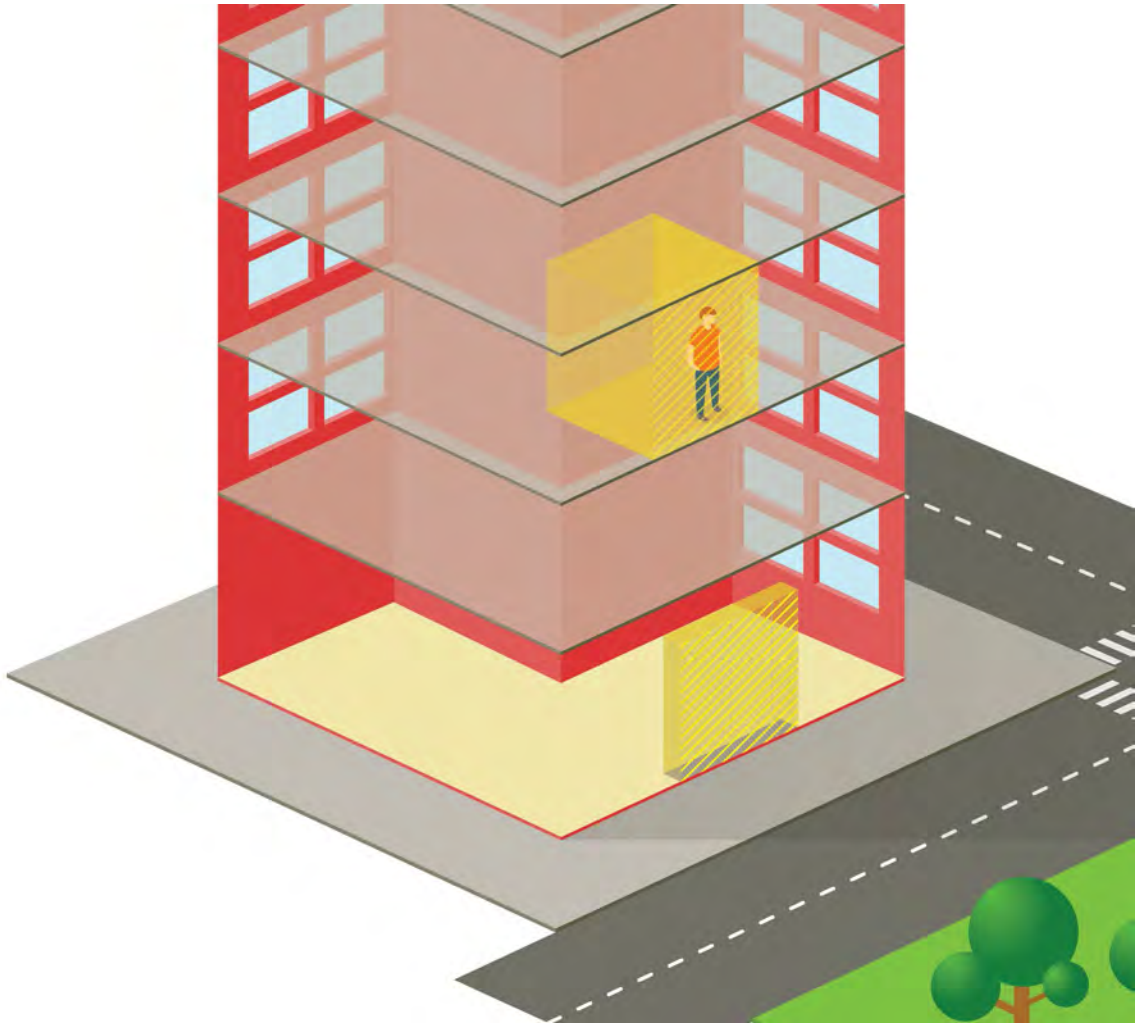
- Civic Address is 1234 NENA Blvd
- Barometric pressure is xx
- System estimates caller altitude is probably about 9 meters
- Floor 2 or 3?
- Do we know if ground floor is “1F” or “G”?
- Which room is the caller in?

Geodetic Information (DBH)



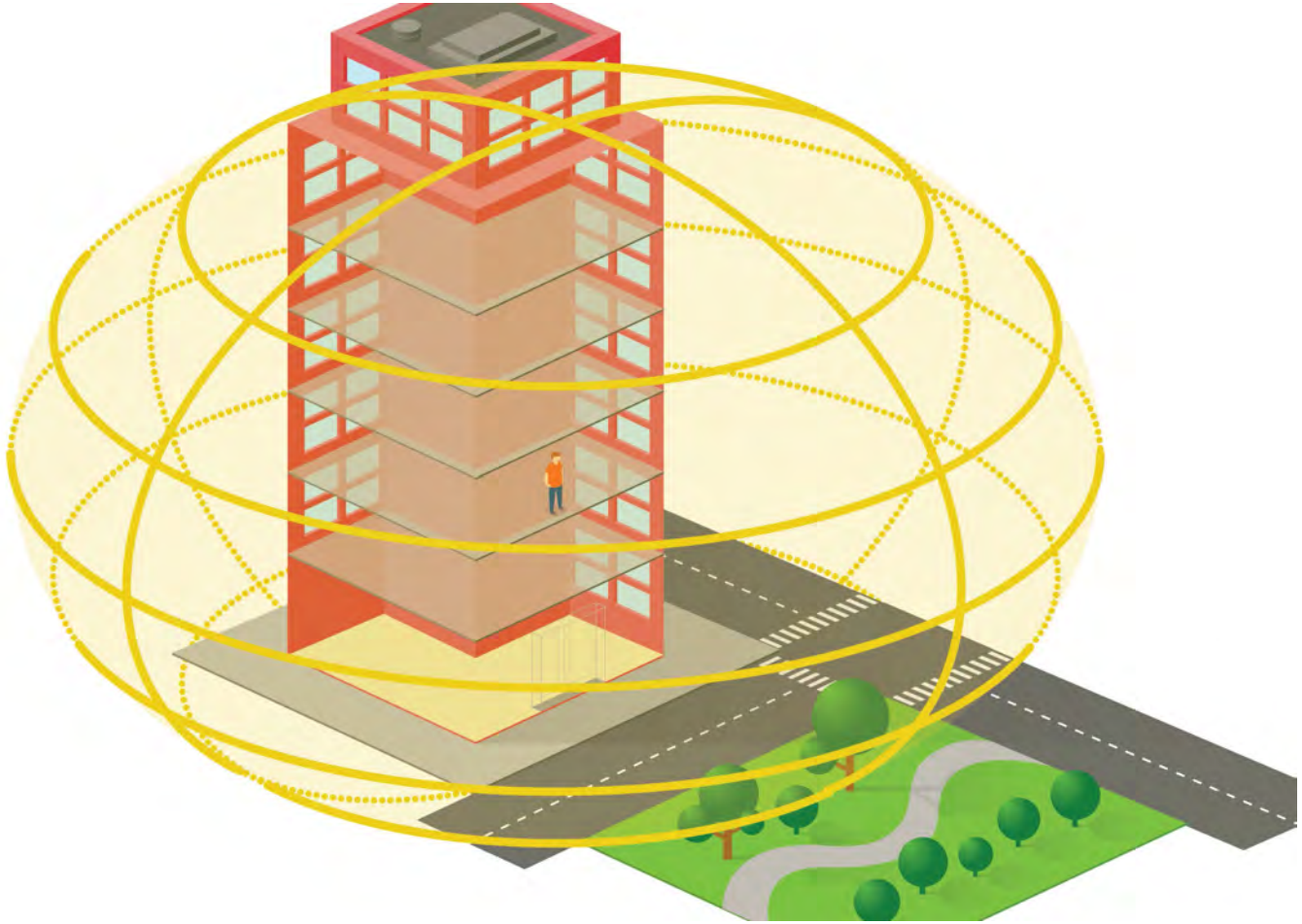
- Caller location is 38.8506697, -77.0593877, 9.12
- Confidence level 5m, 3m
- Establishes a search area
- The caller is probably near the center of the search area
- It is pretty difficult to convey to calltaker and field responder

Civic Address and Suite # (NEAD, Context-Awareness)



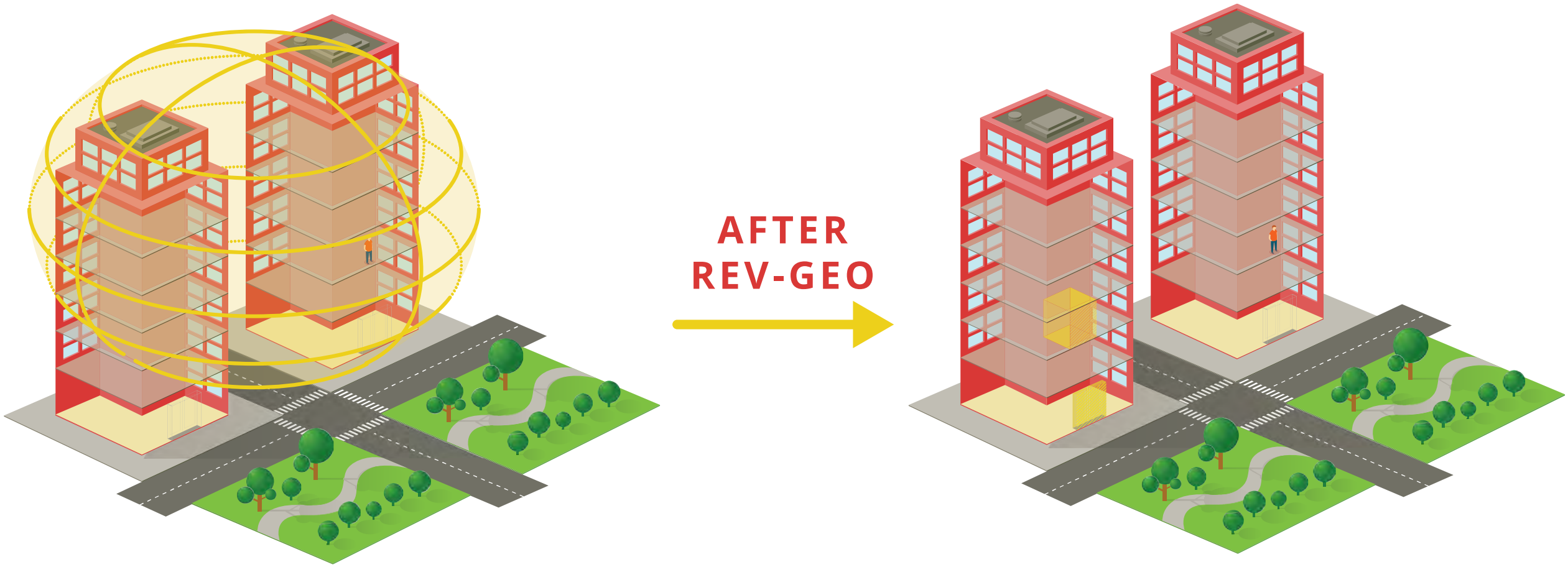
- Civic Address is 1234 NENA Blvd
- Suite number is 200
- As long as it is an apartment or a small office, pretty high confidence of where to go
- If it is a large suite or campus, we at least get to the front door

Sometimes, Uncertainty is Higher

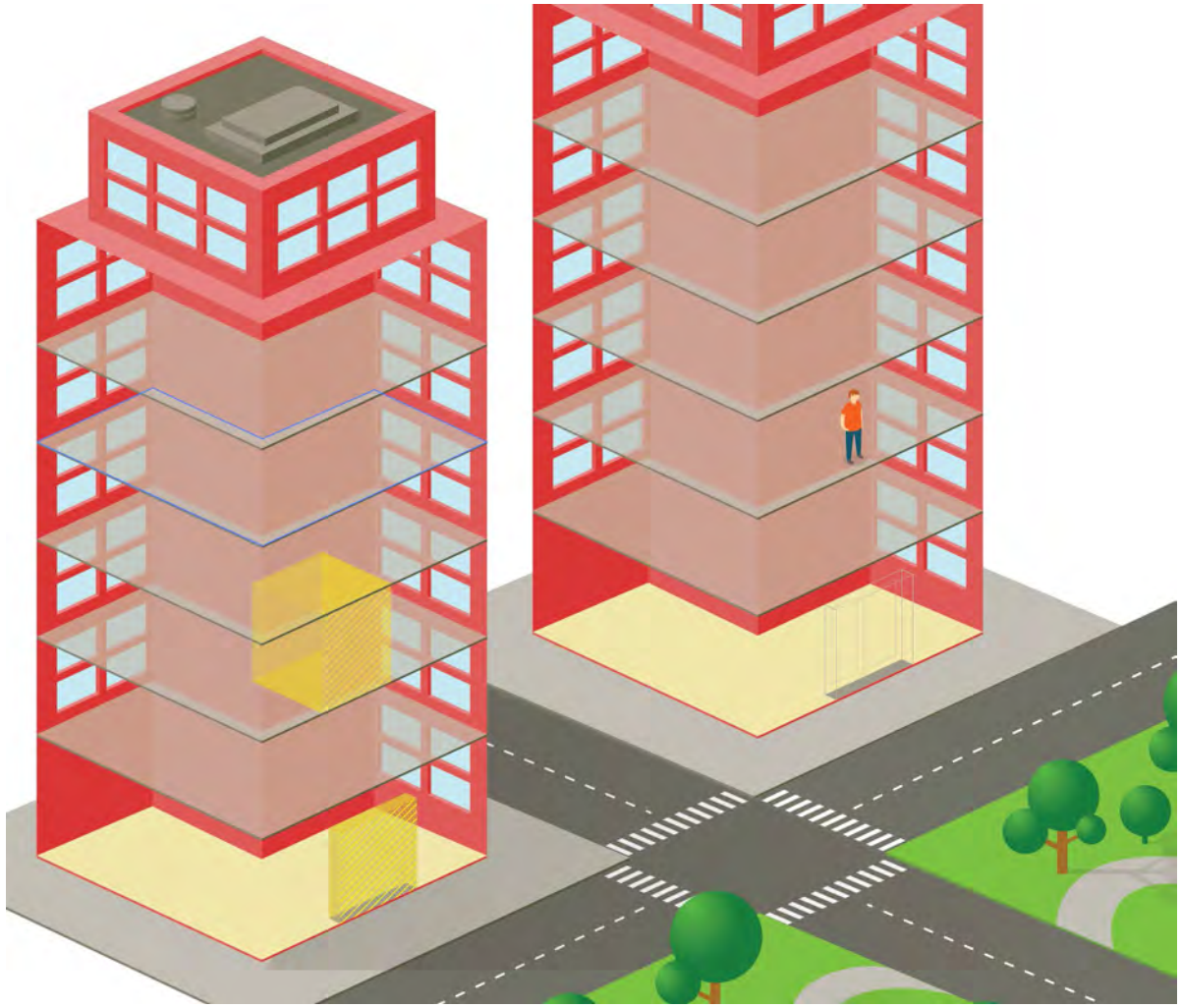


- Caller location is 38.8506697, -77.0593877, 20.12
- Confidence level 60m, 30m
- We don’t always have the luxury (especially indoors) to get a good fix
- Is it helpful to be transparently aware of the level of confidence?
- What should be shown on the screen?
- What should be seen in the field?

The Danger of Perceived Certainty



Geodetic Information (DBH)



- “Confidently-wrong” output (ala Dunning-Kruger effect)
- By presenting a very specific address instead of a location, the responder is told that a caller is at that very specific address
- By presenting a search area, the responder has a degree of confidence about where the individual is located
- Converting a location to a civic address may (will) typically decrease certainty
- Much worse, it could be entirely wrong

The Danger of Perceived Certainty

- “Confidently-wrong” output (Dunning-Krueger effect)
- By presenting a very specific address instead of a location, the responder is told that a caller is at that very specific address, even if wrong
- By presenting a search area, the responder has a degree of confidence about where the individual is located
- Converting a location to a civic address may (will) typically decrease accuracy
- Much worse, it could be entirely wrong

In Closing

- NENA is the only SDO dedicated to 9-1-1
- NENA workgroups are currently active related to today's topic
- If you don't like what you see today, join and contribute
- If we're missing something today, join and have your idea added
- NENA standards get adopted internationally. Why not help develop them?
- NENA is an open standards development organization
- You do not need to be a NENA member to participate in development
- More info at nena.org

Questions?

Brandon Abley
Director, Technical Issues
babley@nena.org

@911NENA911
/911NENA911

NENA
THE 9-1-1 ASSOCIATION