CDE #77099



UNDERSTANDING 9-1-1 MISROUTES

Smarter routing can dramatically reduce secondary transfers and get callers to the right place faster.

By Stephen Martini

It likely happened to you or someone at your agency. You answered the phone to discover a panicked caller on the other end, who launches immediately into grisly details of an emergency. Rapid fire, they tell you where they are, who they are, their phone number and the status of the patient.

There's just one problem: they're not in your jurisdiction. The 9-1-1 call should have been delivered somewhere else.

You want to help but you can't. After all the information they gave you — good, actionable data — you need to stop them and connect them to the right emergency communications center (ECC) so they can start their story over again.

It's time lost.

According to a January 2024 Federal Communications Commission (FCC) Report and Order, it could take as much as a minute for a public safety telecommunicator to determine that a call arrived at the wrong location, gather enough information from the caller to identify the appropriate destination and transfer the caller to the correct communications center, where the closest appropriate response can be dispatched. Compounded over time, this could equal hundreds of thousands of hours spent per year triaging and transferring calls to the right location.

So how does it happen? How do calls wind up in the wrong place, and what can we do to keep it from happening again and again? And what did one state do to significantly reduce the number of secondary transfers its ECCs make every day?

To understand when a call was misrouted, we have to understand how we receive calls in the first place.

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DELIVERING THE CALL

There are two primary delivery paths for 9-1-1 calls: legacy networks and next-generation core services (NGCS), which use Internet Protocol (IP)-based networks. If a call is still traveling traditional copper lines on Centralized Automatic Messaging Accounting (CAMA) trunks — common in rural America and older campuses — it is using a legacy network. If the call is received and delivered across Session Initiation Protocol (SIP) trunks — common in densely populated urban areas and modern corporate campuses — it is using a next-generation network. Routing differs slightly between the two.

Calls traversing a legacy network rely on a selective router to determine where the call goes, based on an Emergency Service Number (ESN) associated with a particular phone number and location. Remember, when 9-1-1 started, calls came only from fixed locations — homes or businesses — with addresses that didn't change, where landline phones with cords hung on walls or sat on kitchen counters.

Each phone number was associated with a specific ESN, associated with a specific ECC responsible for sending help. Initially, the call went to the geographically closest ECC to the caller's location, regardless of whether that was actually in a neighboring city or county. Future improvements routed calls to the ECC responsible for sending the most appropriate public safety response.

Calls traversing a SIP network, like most wireless calls, no longer reference a selective router first for location information. Today, calls can come from anywhere since phones move as often as the people who use them. Providers route calls based on the device's location.

Since most 9-1-1 calls today come from cellular users rather than landlines, 9-1-1 network providers are translating traditional landline addresses into X/Y coordinates in an effort to treat all locations consistently.

Cell phone calls changed the face of 9-1-1 call delivery in the late 1980s and early 1990s, disrupting the reliable network of static phone calls from fixed locations. In the earliest years, cell phone calls delivered voice only — not location information (Wireless Phase 0). Later, calls included the location of the cell tower transmitting the call (Wireless Phase 1), and eventually an approximate location of the caller based on an estimation of the distance between the three closest cell towers (Wireless Phase 2). Calls received by cell towers were IP-based and had to be converted to Time Division Multiplexing (TDM) so they could travel traditional copper lines accessing the 9-1-1 network. Today, those calls remain IP-based and travel a SIP-network delivering straight to the ECC. What once took as long as seven seconds for a call to travel from a caller to the ECC now takes less than two.

Remember that time savings. It will be important when we consider what leaders in Utah considered and implemented.

In fact, many network managers are converting traditional TDM calls to SIP at the closest part of their network to the caller. So a landline caller using copper lines at their house is converted to SIP once their call reaches the nearest central office. That way, the network sees every call as the same and can route them accordingly.

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WHEN TWO BECOME ONE

Calls still arrive in two parts: voice first, then data.

The voice portion travels from the caller to the ECC in milliseconds. You know it's true! Think back to the last abandoned 9-1-1 call you returned — the one where the caller knew they had misdialed 9-1-1 and hung up immediately, before they even heard the line connect, but you still received the call.

That's how fast voice audio can travel on SIP networks today.

But the location of the device or any other data associated with it — health information, vehicle data or additional caller data — still needs to be retrieved from another source: the location information server (LIS).

The LIS contains precise device-based locations, either via X/Y GPS coordinates or street address data, and is currently provided when requested by the network provider. Each call is associated with a Pseudo-Automatic Number Identifier (P-ANI), which is connected with the location data in the LIS. The carrier provides the P-ANI to the LIS, which then provides the location information associated with that specific phone number. It happens in milliseconds.

Rich Johnston, senior solutions engineer with Intrado, remembers how the ECCs were impacted by the transition to SIP connections.

"When we were cutting over the first [ECCs], local leadership were saying 'this is actually worse,' because calls were getting to the [ECC] so fast that the wireless carriers didn't have enough time to get the X/Y (the location of the caller)," Johnston said. "So they would display Phase 1 first and then do a rebid and get Phase 2. Before, on legacy networks, [ECCs] saw Phase 2 delivered immediately and we had to have that conversation. You're getting the call much faster now — five seconds faster than you were before. And it seems counterintuitive because the location didn't arrive first, but it was better."

Johnston estimates 60% of 9-1-1 calls in rural areas around the nation are delivered with the correct device-based location the first time, with that figure exceeding 80% in urban areas. In either case, he says it takes less than two seconds to retrieve the device location from carriers.

In Utah, leaders at the Utah Communications Authority engaged with ECC leaders to consider improving those estimates. Partnering with Motorola Solutions as the statewide NGCS provider, Executive Director Tina Mathieu and 9-1-1 Subject Matter Expert Melanie Crittenden engaged in conversations with ECC leaders about the value of waiting to deliver both the voice and data portions of a 9-1-1 call until the carrier provides the device-based location. The goal was to reduce secondary transfers across the state. According to a 2019 audit report, estimated transfers were as high as 10% of the total 9-1-1 call volume annually.

But waiting to deliver the call until securing the device-based location still introduces a delay — even if the difference is only milliseconds.

"Motorola said we can deliver calls based on location-based routing but we would have to hold the call for just under two seconds," Crittenden recalled. "Obviously, when you look at that, that's a delay. There's no way we can say yes to that. And, by all means,

we're not going to say yes on behalf of the nearly 30 [ECCs] at the time because that's not our decision."

So Crittenden worked alongside Motorola network architects to explain the long-term benefits of waiting an additional second to deliver the call.

"The technology-savvy in the group said 'That sounds right and appropriate to me — I think we should move forward with that,'" Crittenden said.

The solution went live in 2023.

Using statewide Emergency Communications Analysis and Reporting System (ECaTS) data analytics, leaders quickly learned that waiting one second to deliver a call with device-based locations reduced secondary transfers by 50%. Month-over-month through the first quarter, total call volumes increased 7% to 15% but secondary transfers decreased 48% to 52%, saving 11 to 13 hours each month in call routing delays.

At the time, Mathieu remarked: "What is really exciting about this is the fact that there is absolutely no work required on the part of the [ECCs]. The outcome is a result of what's being done through technology. We are finally in a position to maximize the technology and make a major difference in our service level. I don't think in my 30 years in the 9-1-1 industry, I can think of a time where technology was this impactful without having to make any adjustments in policy."

HOW THE CALL GETS LOST

With all this background, you should be thinking it's a miracle of technology the call is ever delivered to the right ECC in the first place. But calls can still get lost and, when they do, misroutes occur.

Whether traveling a legacy or next-generation network, calls must be associated with locations. If the ESN in the selective router is entered incorrectly — those lists are configured by people manually entering addresses into systems, after all — the call can go to the wrong place.

If the selective router is missing information completely, the call will be default-routed to wherever calls go when no recorded location is found. That default route is often identified by the individual ECC, whether the call goes to a neighboring agency or another larger regional ECC. The same is true if the LIS comes up empty. If the device location can't be determined, then the network provider looks for an ESN for the tower. If they can't find an ESN, they'll default route to another ECC as determined by shell records.

By what?

Yep — shell records: placeholder addresses like "Wireless Caller, Tampa, FL" associated with the P-ANI if nothing else is available.

How often does this happen?

Incredibly rarely, according to Johnston.

"These systems are very well controlled and verified. Lots of conversation goes between the [ECCs] and the 9-1-1 system providers to make sure we're doing it the right way. All of that is pre-tested before it's turned live so it would require some sort of database being down to result in an alternate or default route. But those instances are incredibly rare."

THE VOIP/VOICE OVER WI-FI EFFECT

The most recent challenge in routing 9-1-1 calls involves Voice Over Internet Protocol (VoIP) or Voice over Wi-Fi solutions. These calls come from devices that rely solely on the internet to place a call and depend on the user to configure the device's current location whenever they move the phone, laptop or other internet-connected device. If the



location is not configured appropriately, the call will route to the last address provided, which could be a home office across the country while the user is working from a hotel room far away.

The Federal Communications Commission (FCC) is actively looking at location accuracy requirements for Voice over Wi-Fi. Further, the FCC is continually examining location accuracy requirements to strengthen them across services, so it's possible its rules could change in the future. APCO remains focused on supporting voice call paths, no matter how they originate.

In August, APCO Chief Counsel and Director of Government Relations Nicole McGinnis addressed attendees at APCO's annual conference in San Antonio, Texas, about the critical foundation the voice call provides while keeping an eye on future capabilities.

"A caller may have text, video, photographs and precise location information in the palm of their hand — but the most important call they ever make may still be limited largely to voice," she said. "The most consequential communications should not be the least technologically capable. Next Generation 9-1-1 (NG9-1-1) can change that. It can provide richer information, stronger security, and greater situational awareness for ECCs and field responders. APCO has long believed that the federal government has a vital role to play in ensuring no community — urban, rural, suburban or tribal — is left behind as we modernize our nation's 9-1-1 infrastructure. That requires a national framework and federal funding." ●

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1. According to a January 2024 FCC Report and Order, how much time is lost due to misrouted 9-1-1 calls?
   a. 30 seconds
   b. 1 minute
   c. 2 minutes
   d. 3 minutes

2. 9-1-1 calls are routed to ECCs on which two primary types of networks?
   a. Copper and silver
   b. Legacy and IP-based
   c. Old and new
   d. Good and bad

3. Legacy networks rely on CAMA trunks to route 9-1-1 calls.
   a. True
   b. False

4. Calls on modern IP-based networks are delivered via Session Initiation Protocol (SIP). How much faster can calls reach the ECC compared with legacy network calls?
   a. 2 seconds
   b. 4 seconds
   c. 5 seconds
   d. SIP calls are not delivered faster

5. On a legacy network, Emergency Service Number (ESN) is used by which network element to determine where a 9-1-1 call should be routed?
   a. Selective router
   b. Internet modem
   c. Emergency database
   d. Carrier network

6. Modern IP-based networks featuring next-generation core services (NGCS) route the call using what information?
   a. The caller's phone number
   b. The location of the cell tower the caller is near
   c. The caller's home address
   d. The location of the caller's device at the time of the call

7. What role can a selective router play in an NGCS network?
   a. No role
   b. A primary method of routing calls
   c. Alternate or default routing if the caller's location can't be determined
   d. The role of Banquo in Macbeth

8. Most major carriers convert calls to SIP, regardless of how they originate, for consistency when routing calls across the network.
   a. True
   b. False

9. According to Rich Johnston, approximately what percentage of 9-1-1 calls are delivered with the correct device-based location on the first attempt?
   a. 60% in rural areas and more than 80% in urban areas
   b. 20% in rural areas and 40% in urban areas
   c. 15% in rural areas and 85% in urban areas
   d. 100% in both rural and urban areas

10. After deciding to require the NGCS to hold all calls until the device location was acquired, the Utah Communications Authority saw approximately what reduction in secondary transfers?
    a. 70-75%
    b. 48-52%
    c. 20-24%
    d. 0%

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