ITUWebinars

Signalling Security

Enhancing signalling security and privacy using globally interoperable digital signatures

16 June 2022
15:00-17:00, CEST

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https://itu.int/go/WB-SSP-01

Agenda

- Overview of the SS7 signalling network and main use cases
- Current security issues in signalling protocols
- Available mitigations and their limitations
- Applying globally interoperable digital signatures signalling messages: ITU-T Q.3057 and draft Q.Pro-Trust.
- Use cases for application of Recommendations for improving signalling security: CID (over interconnect) and Roaming

A little about myself

- Husband, father (+2), geek 8-)
- Security researcher for the last 18 years
  - Specialize in telecom, IoT & blockchain
  - Editor of ITU-T Study Group 11 recommendations
  - Member of FIGI SIT WG & DFGI SA WG
- Handles:

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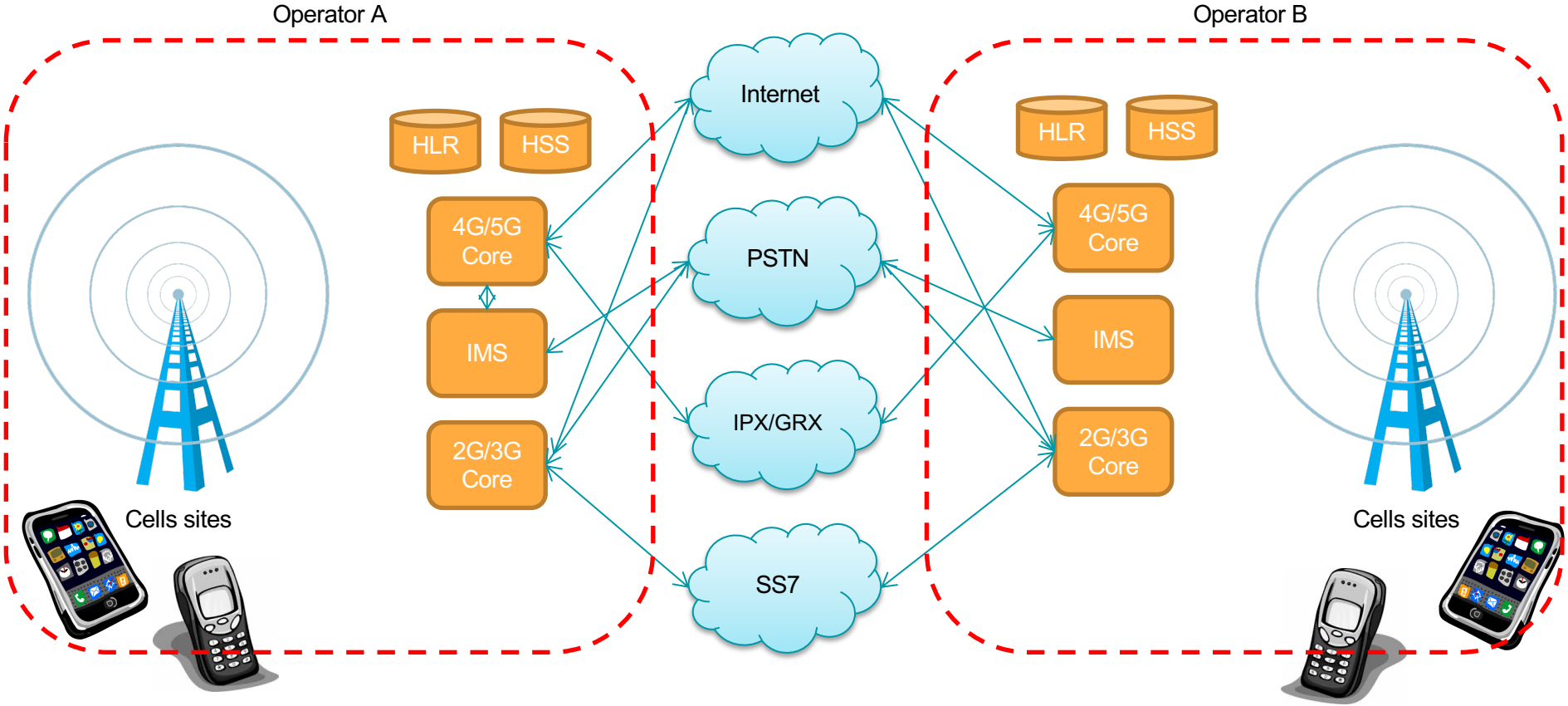
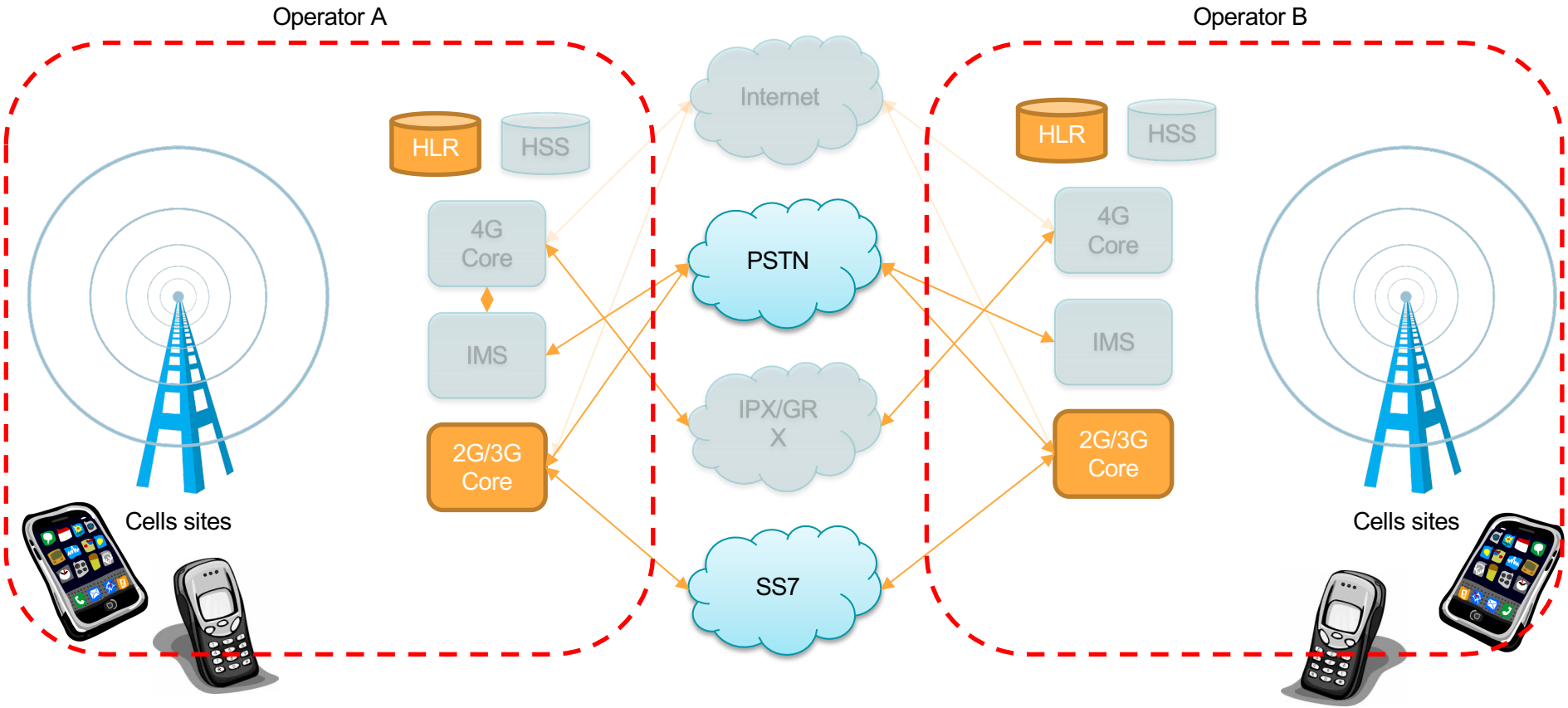
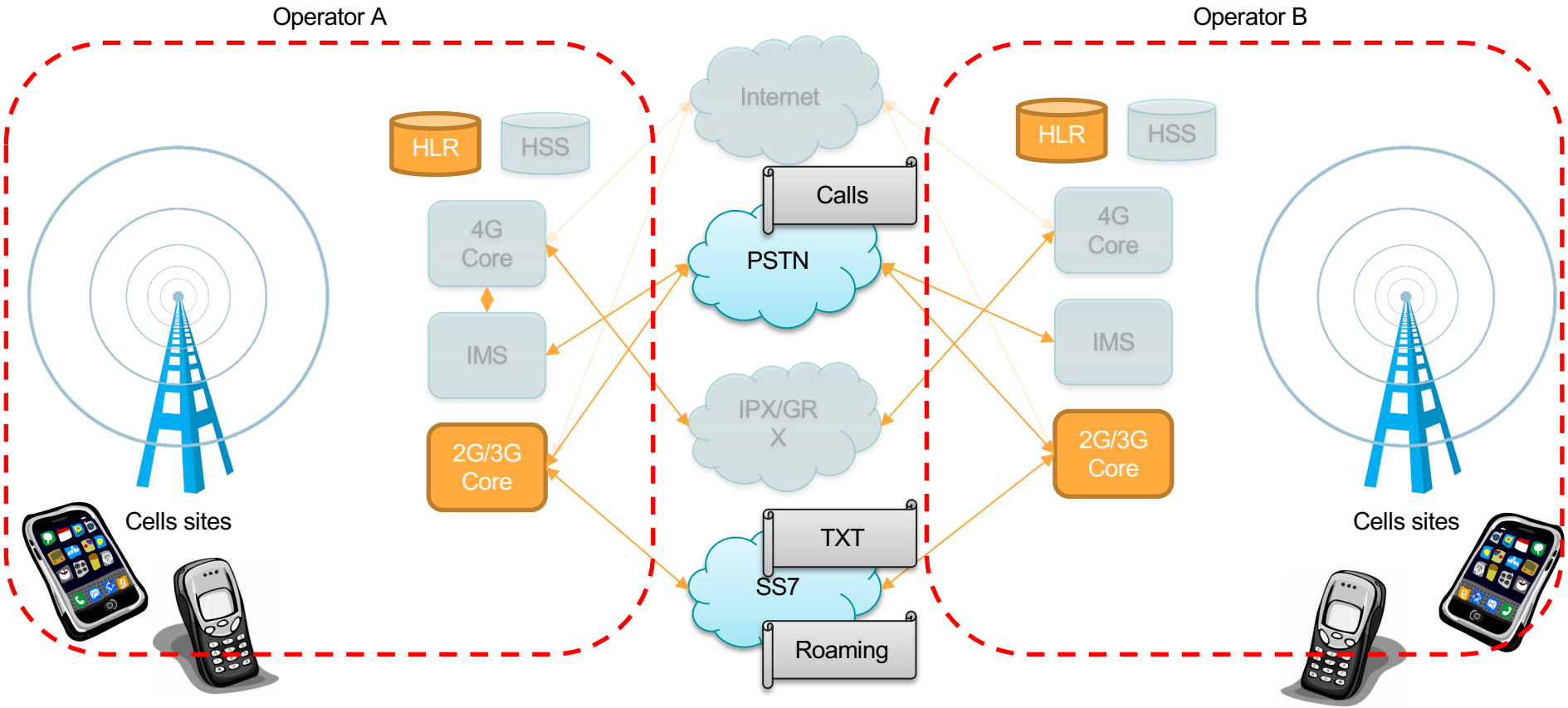
Telco’s core network (very high level)



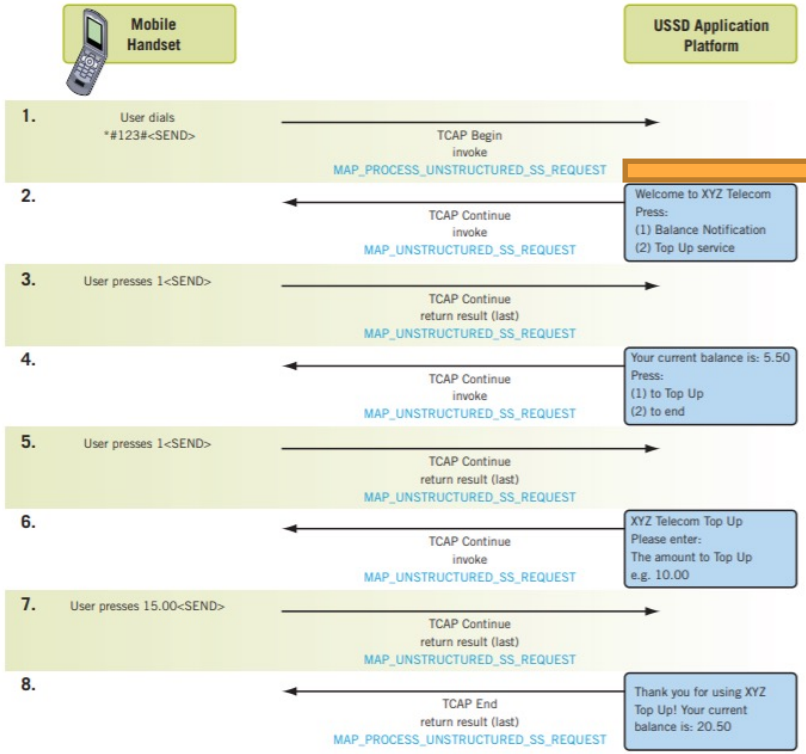
The scope of SS7



Telecom services over SS7



Example: MO USSD call flow

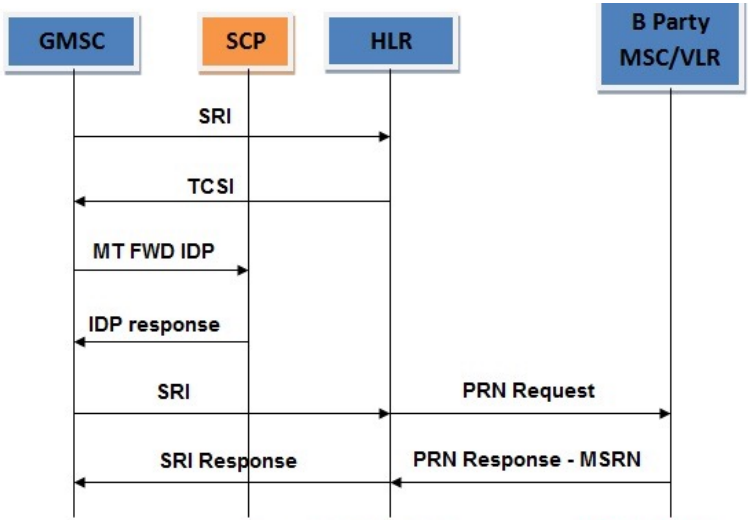


No.	Time	Source	Destination	Protocol	Length	Info
1	13:08:00.624000	1041	8744	GSM MAP	218	invoke processUnstructuredSS-Request

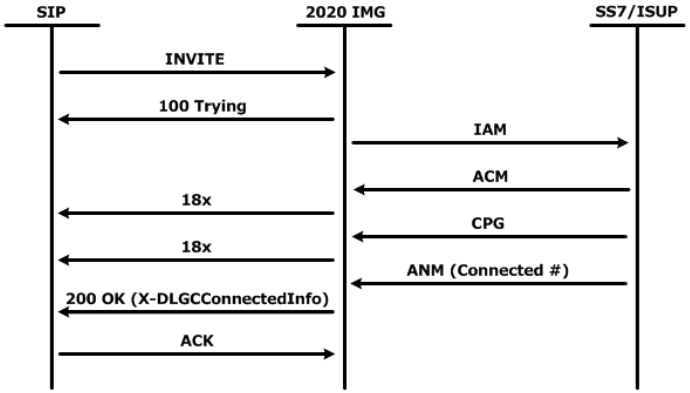
```
> Frame 1: 218 bytes on wire (1744 bits), 218 bytes captured (1744 bits)
> Ethernet II, Src: Private_01:01:01 (01:01:01:01:01:01), Dst: MS-NLB-PhysServer-02_02:02:02:02 (02:02:02:02:02:02)
> Internet Protocol Version 4, Src: 1.1.1.1, Dst: 2.2.2.2
> Stream Control Transmission Protocol, Src Port: 2904 (2904), Dst Port: 2904 (2904)
> MTP 2 User Adaptation Layer
> Message Transfer Part Level 3
> Signalling Connection Control Part
> Transaction Capabilities Application Part
v GSM Mobile Application
  v Component: invoke (1)
    v invoke
        invokeID: 1
      > opCode: localValue (0)
      > ussd-DataCodingScheme: 0f
      v ussd-String: aa180da682dd6c31192d36bbdd46
          USSD String: *140*0761241377#
      v msisdn: 917267415827f2
          1... .... = Extension: No Extension
          .001 .... = Nature of number: International Number (0x1)
          .... 0001 = Number plan: ISDN/Telephony Numbering (Rec ITU-T E.164) (0x1)
        v E.164 number (MSISDN): 27761485722
            Country Code: South Africa (Republic of) (27)
```

Other Examples

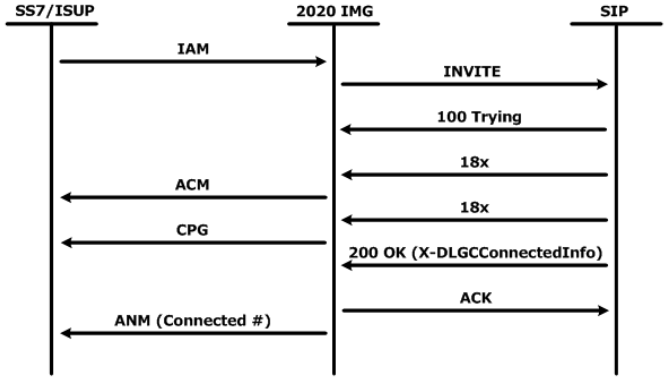
ISUP Roaming call flow



SIP to ISUP call

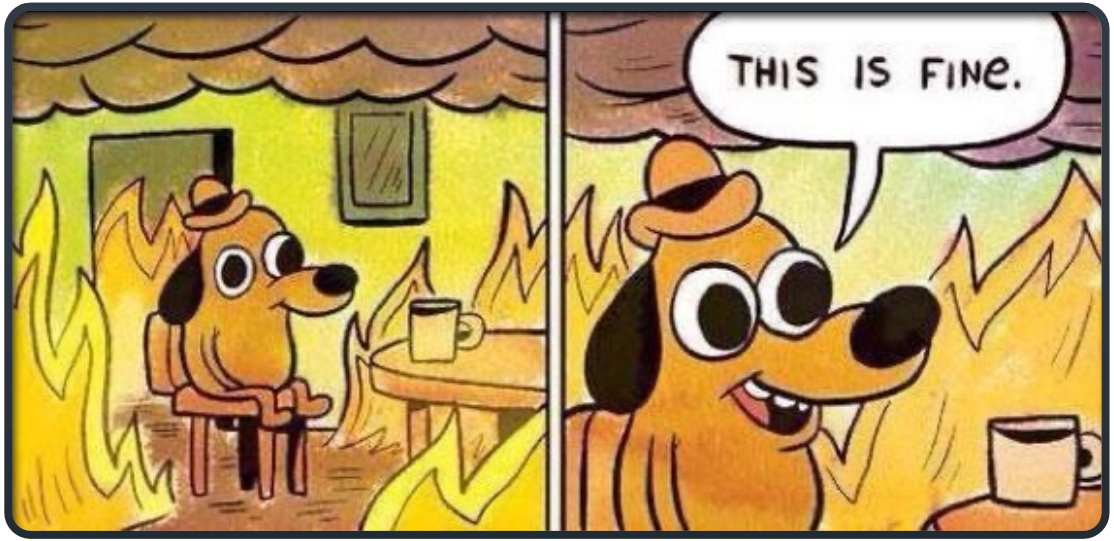


ISUP to SIP call

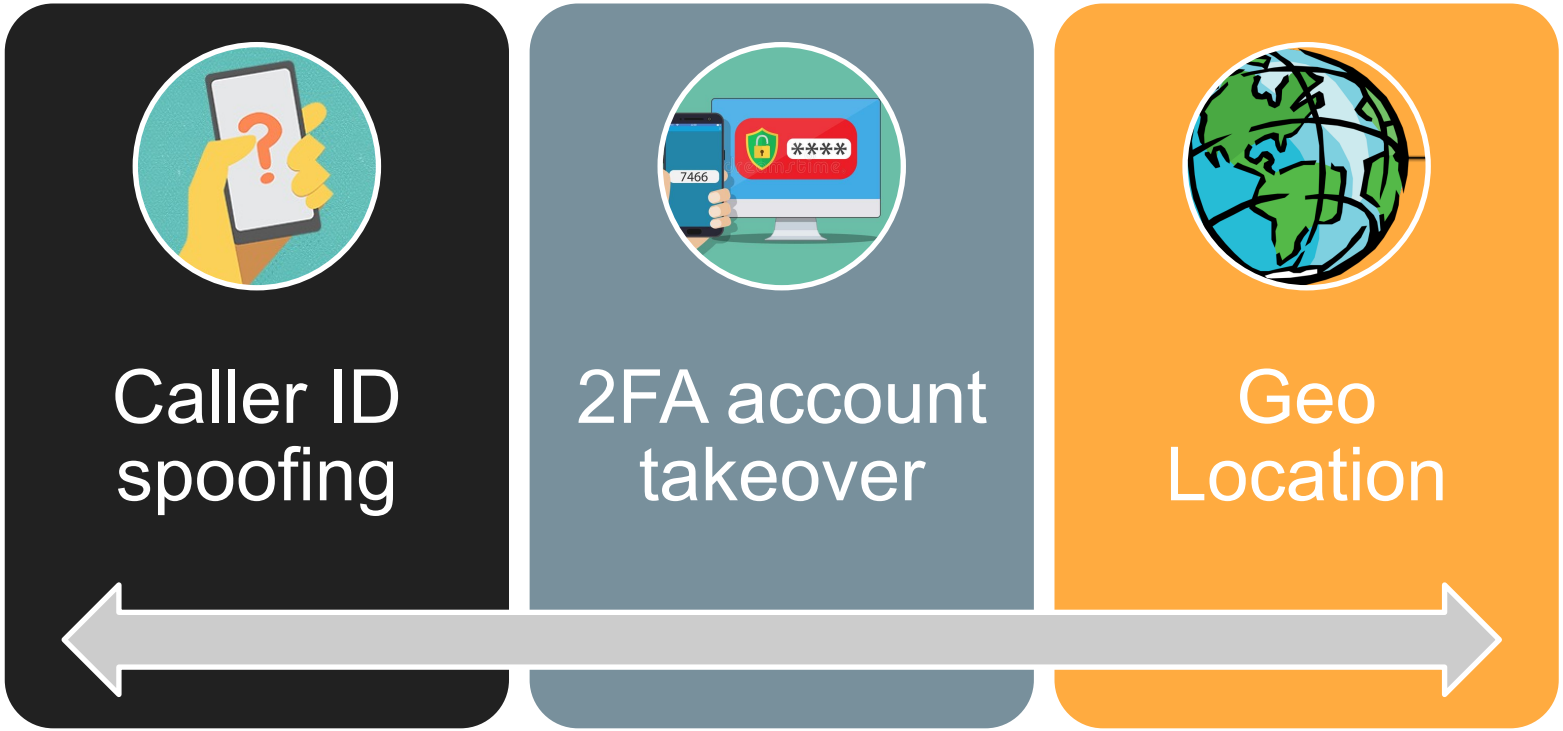


SS7: vulnerability by design

- Flat network (switched, not routed, no NATs)
- Static address allocation (ITU managed)
- All network elements are trusted without question
- No encryption
- No authentication required to join the network

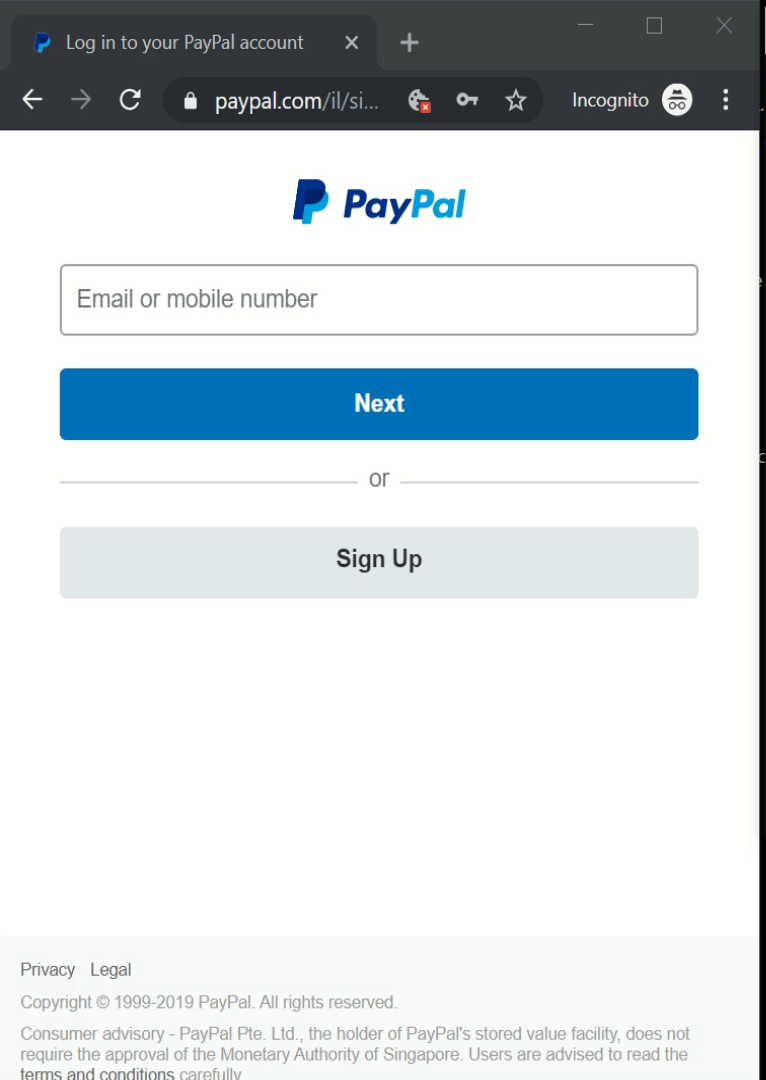


Major types of signaling attacks in the wild



2FA SMS interception

Example


Log in to your PayPal account
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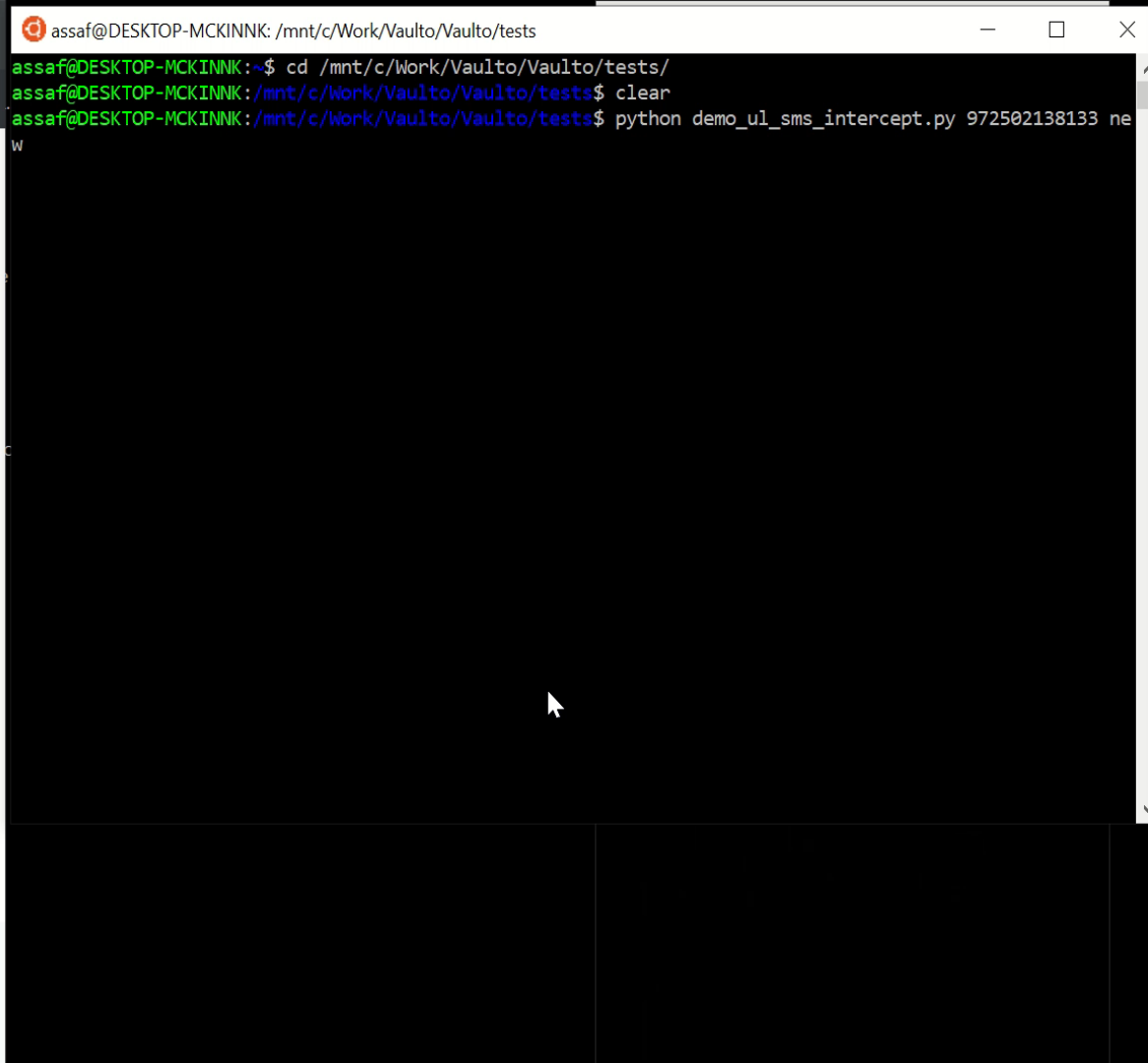

assaf@DESKTOP-MCKINNK: /mnt/c/Work/Vaulto/Vaulto/tests
assaf@DESKTOP-MCKINNK:~$ cd /mnt/c/Work/Vaulto/Vaulto/tests/
assaf@DESKTOP-MCKINNK:/mnt/c/Work/Vaulto/Vaulto/tests$ clear
assaf@DESKTOP-MCKINNK:/mnt/c/Work/Vaulto/Vaulto/tests$ python demo_ul_sms_intercept.py 972502138133 new

Available Mitigation Measures

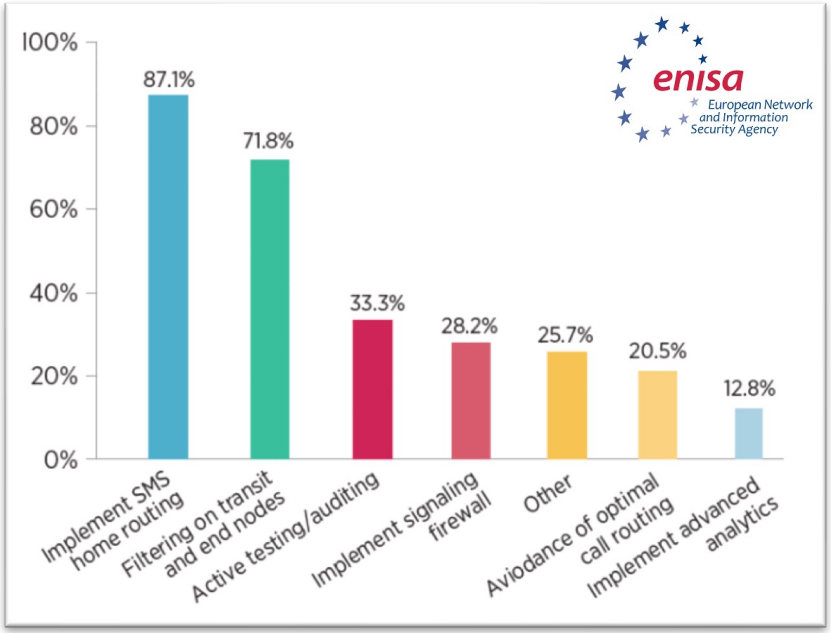
- Implementation of configuration recommendations

Attack	FS.11 (2/3G)	FS.07 (2/3G)	IR.82 (2/3G)	IR.88 (4G)
Spoofing	✓	✓	✓	×
SMS Hijack	×	✓	×	×
Geo Location	×	✓	✓	✓

- Commercial signaling firewalls
  - Stateless vs. stateful
  - Threat intelligence

Limitations of available mitigation measures

- Implementation of configuration recommendations
  - Doesn’t solve attacks using legitimate signaling flows
  - Low adoption by operators
- Commercial signaling firewalls
  - Low adoption by operators
  - Threat intelligence depends on attack information sharing between operators



The solution

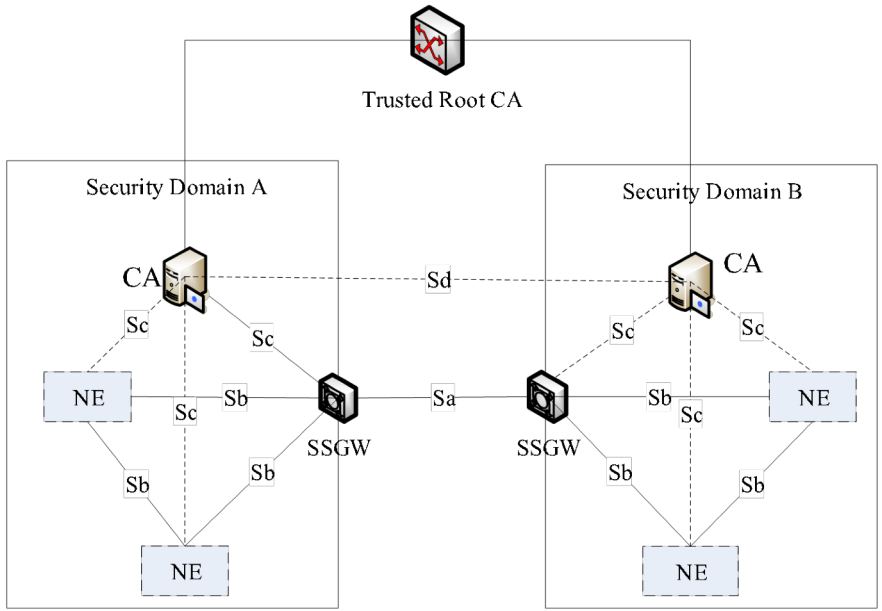
- Adding an integrity layer to signaling transactions to enable trustable communications
- Some example of applications:
  - Calling Line Identification (CLI) authentication
  - 2FA
  - Digital Financial Services (DFS)
  - And more…

But didn’t we already try that?

- TCAP-SEC was released in the early 2000’s but was never adopted
  - Did not specify the trust model
  - Used crypto that wasn’t “mainstream” (i.e. did not use PKI)
  - Did not specify any governance or policy regarding issuance of authentication keys

Current work in SG11

- ITU-T Q.3057 and ITU-T Q.Pro-Trust
  - Adds digital signature to SS7 signaling to authenticate the sender
  - Prevents hackers from impersonating legitimate network functions on the SS7 network
  - Enables operators to manage trust of other operators
  - Using TLS 1.3 as a reference trust model
- ITU-T Q.CIDA
  - Uses *Q.3057* and *Q.Pro-Trust* as infrastructure for CLI authentication
  - Uses authentication tokens to prevent CLI spoofing



But what about the trust model?

In Nov. 2021 SG11 and SG2 had a brainstorming session regarding this issue

The main takeaways from this session were:

Trust model

- We will need to build a hierarchy of trust, country/regional first, then global. where each local regulator will have to determine how to implement the certification depending on their local forms of identification and rules
- **Technically the digital certificates must be interoperable across domains** (SIP, SS7 and others).
- This trust chain and certification standard must account for the fact that numbering is no longer geographical and different authorities can govern the same numbering range
- **The trust anchor needs to be a globally trusted SDO**, preferably one already in charge of numbering and this anchor must interoperate with existing repositories (such as the ones in the US and Canada)

vetting/certification process

- **We will need to formulate a way to standardize these local/regional certification processes** in order to keep the bad actors out. This standardization process should involve as many counties as possible in order to improve its applicability on the global scale
- The certification process implemented in the US and Canada for STIR/SHAKEN is a good use case to learn from in order to standardize it on the global scale
- These certification process standardization must be connected to a largely accepted digital identity management frameworks for the operator plane and for the individual plane

US & Canada use case

FCC developed the STI (Secure Telephone Identity) framework, which is comprised from:

- STI-GA – Governance Authority
  - Managed by a board consisting of representatives from across the telecom industry
  - Defines the policies and procedures for which entities can acquire a digital certificate
  - Can revoke a service provider's certificate due to breach of trust
  - Selects the STI Policy Administrator
- STI-PA – Policy Administrator
  - Approves STI-CAs
  - Validates that service providers are authorized to obtain STI Certificates
  - Maintains a secure list of all authorized STI-CAs and Certificate Revocation List (CRL)
- STI-CA – Certification Authority
  - Issues STI Certificates to service providers

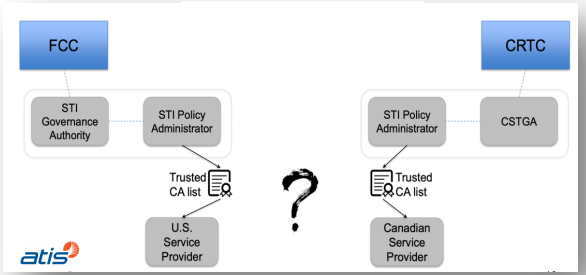
- GBSD
- Metaswitch
- NetNumber
- Neustar
- Sansay
- PeerhingHub
- TransNexus

STI Framework on the signaling level

- IETF STIR (RFC 8224-6) for adding authentication token to SIP headers
  - PKI based token (JWT encoded) – modeled after TLS
- Authentication is done cross-operator, which means:
  1. Only calls that cross between operators are signed
  2. Each cross-operator call is signed with the same operator certificate, i.e., the CLI itself is not signed, only the originating operator's identity is asserted
  3. A valid certificate indicates to other operators that the call is not a robocall nor is it spoofed
  4. Each operator is mandated by the STI-PA to verify internally that it does not provide service for robocalls and/or CLI spoofers
  5. If the STI-PA receives reports that robocalls of spoofed calls originate from an operator holding a valid certificate, it can petition the STI-GA to revoke the operator's certificate

Open issues in STI

- International interoperability



- Trust Anchor - according to NANC report
  - The STI framework will not “solve” illegal caller ID spoofing, but it is an enabler that can lay the groundwork for a variety of techniques to address the problem
  - Establishing the Call Authentication Trust Anchor, a secure certificate management infrastructure will provide the necessary building block for securing the call authentication

ITU-T Q.3057 & Q.Pro proposed trust model

- Each operator is assigned a digital certificate by the TSCA (the trust anchor)
- A provisional certificate is issued via API (machine verifiable)
  - The provisional certificate is valid for only 6 months
- A certificate is issued by TSCA after verifying the requestor's identity
  - The full certificate is valid for 2 years
- The TSCA can entrust a national/regional CA (Certification Authority) to issue the operator certificates
- Each operator holds its own CA which works in a hierarchical trust chain: operator → national/regional CA (if applicable) → TSCA
- Certificates are ITU-T X.509 (same as in TLS) which are interoperable with STIR
- The TSCA can revoke a rouge operator (bad actor) certificate, excluding them from the SS7 network

Next steps

- We will need to formulate a way to standardize these national/regional certification processes
- Standardize a governance policy to govern national/regional certification authorities, including certificate revocation
- To achieve true end-to-end authentication of caller identity the proposed framework needs to be connected to a largely accepted and adopted personal digital identity management framework
- Establishment of a global trust anchor which will aggregate a repository of approved CAs which can verify certificates (operator or personal)
- Standardize an IWF (Interworking Function) between ITU-T X.509 and RFC 8226

Open discussion

Thank you

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