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NICC Document

Guidelines for the Security of All IP Telephony (All IPT) Service in the UK Telecommunications Network

NICC Standards Limited

The Old Rectory
Church Street
Weybridge
Surrey KT13 8DE

Tel.: +44(0) 20 7036 3636

Registered in England and Wales under number 6613589

The Technical Secretary, NICC Standards Ltd,

PO Box 3090, Eastbourne, BN21 9HA

secretary@niccstandards.org.uk

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Foreword

This NICC Document (ND) has been jointly produced by NICC Security and All-IP Task groups.

Introduction

All CPs must secure their voice services over the access network and this document gives guidance on the areas that must be considered when securing an (All) IP Telephony [IPT] service.

The purpose of this document is to offer security best practice to be used by the industry and anyone involved in the design, operation and management of PATS voice services (a service available to the public for originating and receiving national and international calls) within the VOIP ecosystem.

As technology evolves, so do the threats of malicious activity and, with the evolution of artificial intelligence, this **may** compound today's challenges in securing our networks. Events could be from an intended action or simply poor practice. As such, the All IP Telephony (All IPT) Service must use security best practice in the UK Telecommunications Network~~.~~ It is often the lack of basic security hygiene that leads to a malicious activity and as such the document will aim to highlight fundamental areas of security best practice as well more technology specific items.

1 Scope

This document makes recommendations for security best practice to be implemented by the owning CP on the network platform (including IPT CPE) for the IPT services it provides.

All **IPT** is a fixed line PATS replacement service, so it does not include smart devices that are not fixed to a location. The SIP soft phone client running on wireless broadband internet is also out of scope for the purposes of this document.

NNI interfaces are out of scope for this document; for detail relating to this see normative reference [2].

2 References

2.1 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] BSI Standard ISO 22301 Business Continuity Management
[2] NICC ND1647 SIP-NNI Basic Voice Architecture**.**
[3] NICC ND1704 End-to-End Network Performance Rules & Objectives for the Interconnection of NGNs.
[4] FCS Fraud Mitigation Standard Specification.
[5] NICC ND1438 Voluntary Code of Practice. Mitigating Theft of Service from End User Voice over IP
Communications Systems.
[6] NICC ND1431 Guidance on CPE Compatibility on NGN and NGAs
[7] NICC ND1033 NGA Telephony SIP User Profile
[8] General Licence Conditions (General Condition C6 requires communications providers to provide CLI facilities)
[9] Code of Practice Ofcom - Guidance on the provision of Calling Line Identification facilities and other related services
[10] NICC ND1016 Requirements on Communications Providers in Relation to Customer Line Identification Display
[11] NICC ND1439 Guidance for Implementing ND1016 in SIP networks

2.2 Informative references

[i1] National Cyber Security Centre. 10 Steps to Cyber Security. Updated: 09 Aug 2016.
[i2] National Cyber Security Centre. Introduction to the NIS Directive. Updated: 30 Apr 2016.
[i3] National Cyber Security Centre. Security operations centre (SOC) buyer's guide. Updated: 24 Sep 2016.

[i4] Information Commissioners Office. Data Protection impact assessment.
[i5] Information Commissioners Office. Data protection by design and default.
[i6] GOV.UK Cyber Essentials Scheme: overview.
[i7] National Cyber Security Centre: Self-help for Cyber Essentials.
[i8] TUFF – Telecommunications UK Fraud Forum (CSG (linked to TUFF).
[i9] Action Fraud – National Fraud & Cyber Reporting Centre.
[i10] CIfas – Cross-section fraud sharing organisation.
[i11] ACFE – Association of Certified Fraud Examiners.
[i12] DECT.org CAT-iq Certified products.
[i13] ETSI Network Function Virtualisation
[i14] NIST Special Publication 800-81-2. Secure Domain Name System (DNS) Deployment Guide.
[i15] Cyber Security Information Sharing Partnership (CiSP).
[i16] CBEST Intelligence-Led Testing - Understanding Cyber Threat Intelligence Operations

2.3 Conventions

The ETSI Key words are applicable throughout this document.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms apply:

All IP (Telephony) [IPT] Service	All IPT is a fixed line PATS (a service available to the public for originating and receiving national and international calls) replacement service.
CPE and devices	For the purposes of this document, the devices integrated and operated with All IP (Telephony) [IPT] service~~.is~~.
CBEST	CBEST is a framework to deliver controlled, bespoke, intelligence-led cyber security tests. The tests replicate behaviours of threat actors. Setup for the financial services sector but offering excellent documentation resources for wider industry.
Denial of Service	Often a malicious attempt to make a host(s) or network resources unavailable to genuine users temporarily or indefinitely by disrupting the intended functioning of the system(s), for example by flooding it with access/connection requests.”
European Union (EU) General Data Protection Regulation (GDPR)	(GDPR) (EU) 2016/679 is a regulation in EU law on data protection and privacy for all individuals within the European Union (EU) and the European Economic Area (EEA).
Fully Integrated Architecture	Framework based on real-world experience, to provide strong focus on business requirements and drivers, and all aspects of the architecture and all architectural decisions are traceable.
Hashing Functions	A hash is an outcome of the cryptographic algorithm mathematical function that takes an input string and generates an outcome that is irreversible unique string of alphanumeric characters such that no two hash outcomes are ever the same irrespective of length and format of input string. Examples of hashing algorithms are:MD5, RIPEMD, Whirlpool, SHA-1, SHA-2 and SHA-3.
Hybrid Architecture	Using a mix of technologies and platforms but having a centralised approach.
NFV	Network functions virtualization (NFV) defines standards for compute, storage, and networking resources that can be used to build virtualised network functions.
PIN Codes	Personal Identification Number: **may** be numbers only, or combination of numbers and letters, dependant on the CPE device type.
Passphrase	A string of characters that allows access to a computer, interface or system.
Red Team	Taken from a military term. Defined loosely, red teaming is the practice of viewing a problem from an adversary or competitor's perspective.
Salt	Salt cryptography. A "salt" is a value used to modify a hash of a password.

SD-WAN	Software-defined wide area network (SD-WAN) is a specific application of software-defined networking (SDN) technology applied to WAN connections, which are used to connect networks.
SIP	Session Initiation protocol. It is a client server communication protocol that is used to set up, maintain and tear down communication sessions, in current scope – voice sessions between IP telephony platforms.
SIP Client (IPT)	A SIP client (UAC) using IP telephony is any network device that sends SIP requests and receives SIP responses. SIP clients connect to SIP servers (UAS).
Theft of Service	The unauthorised use of system functions with the intent of financial gain **or restricting** legitimate use of system resources.
Threat Actor	A threat actor or malicious actor is a person or entity that is responsible for an event or incident that impacts, or has the potential to impact, the safety or security of another entity.
Two factor authentication	Two factor authentication is a second layer of security used to make sure that people trying to gain access to a system are who they say they are. Firstly, a user will usually enter their username and a password. Then, instead of immediately gaining access, they will be required to provide another piece of information. This second factor could come from one of the following categories: • Something you have (e.g. mobile phone) • Something you are (e.g. biometrics)
Voice mail system	A system that provides for a number of “mail boxes” to which callers are directed, when the respective users are unavailable. The “mail boxes” are for the recording of messages from callers. It is usual for voice mail systems to provide a notification to the user that message(s) are waiting. Voice mail systems are often integrated with a call routing or similar apparatus in a manner that enables a caller to dial further digits to select an alternative user.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ATA	*Analogue Telephony Adapter*
B2BUA	*Back to back user agent*
CAT-iq	*Cordless Advanced Technology – internet quality. Enables the DECT (Digital Enhanced Cordless Telecommunications) telephony standard to be used with VoIP and other internet-based services*
CA/RA	*Certificate Authority / Registration Authority*
CMP	*Certificate Management Protocol*
CRL	*Certificate Revocation List*
CP	*Communications Provider*
CPE	*Customer Premises Equipment*
CSR	*Certificate Signing Request*
DECT	*Digital Enhanced Cordless Telecommunications*
DH	*Diffie-Hellman (a method of secure key exchange)*
DMZ	*De-Militarised Zone*
DNS	D*omain* Name System
E2E	*End to End*
IDS	*Intrusion Detection System*
FCS	*Federation of Communication Services*
IP	*Internet Protocol*
IP-PBX	*Private Branch Exchange connected to the PSTN over the Internet Protocol*
IPS	*Intrusion Prevention System*

IPT	*Internet Protocol Telephony*
ISP	*Internet Service Provider*
ITSP	*Internet Telephony Service Provider*
ITSPA	*Internet Telephony Services Providers' Association*
LAN	*Local Area Network*
NNI	*Network to Network Interface*
ONT	*Optical Network Termination*
OCSP	*Online Certificate Status Protocol*
PATS	*Publicly Available Telephone Services*
PEM	*Privacy Enhanced Mail*
PII	*Personal Identifiable Information*
PKI	*Public Key Infrastructure*
PSK	*Pre-Shared Key*
RSA	*Rivest–Shamir–Adleman (a method of secure key exchange)*
RTP	*Real-time Transport Protocol*
SBC	*Session Border Controller*
SIP	*Session Initiation Protocol*
SRTP	*Secure Real-time Transport Protocol*
TLS	*Transport Layer Security*
TR69	*(Technical Report) Management interface for CPE*
VOIP	*Voice over IP*
PBX	*Also known as PABX. Private Automatic Branch Exchange*
UNI	*User to Network interface*
X509	*ITU-T standardised format of the certificate file*

4 All-IP Telephony Architecture overview

The All IPT Architecture will be determined by the owning Communication Provider (CP). For the purposes of this document, the All IPT architecture is based on the diagram in Figure 1 below."

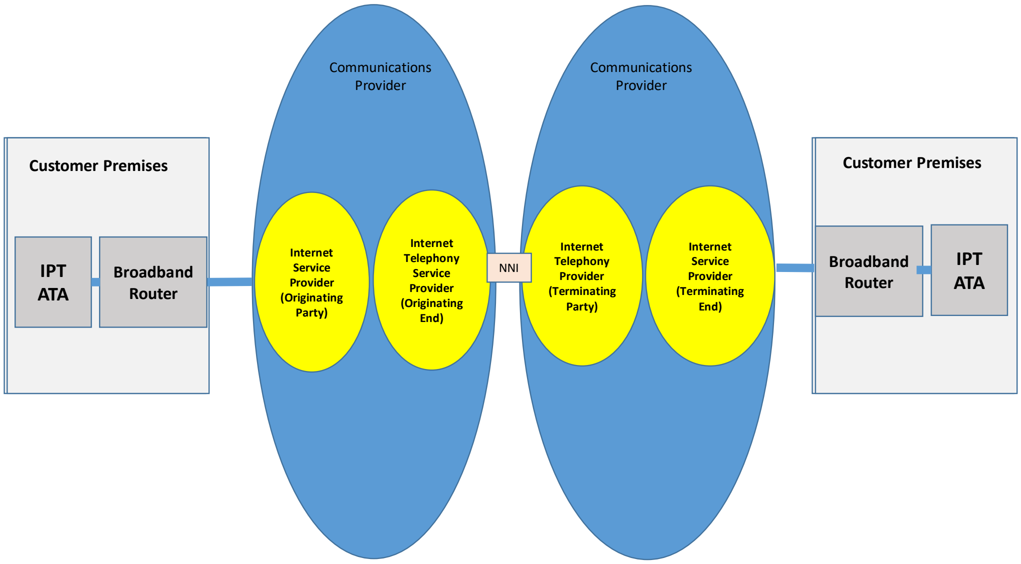

Customer Premises
IPT ATA
Broadband Router
Communications Provider
Internet Service Provider (Originating Party)
Internet Telephony Service Provider (Originating End)
NNI
Communications Provider
Internet Telephony Provider (Terminating Party)
Internet Service Provider (Terminating End)
Customer Premises
Broadband Router
IPT ATA

Figure 1: Generic Architecture

Typically, CPE to IPT Platforms use;

- SIP for signalling, and
- RTP for media

With an option to use TLS to secure SIP signalling and SRTP for added media security.
The NGA Telephony SIP User Profile is defined in ND1033 [7]

The end to end All-IPT architecture comprises the following functional blocks;

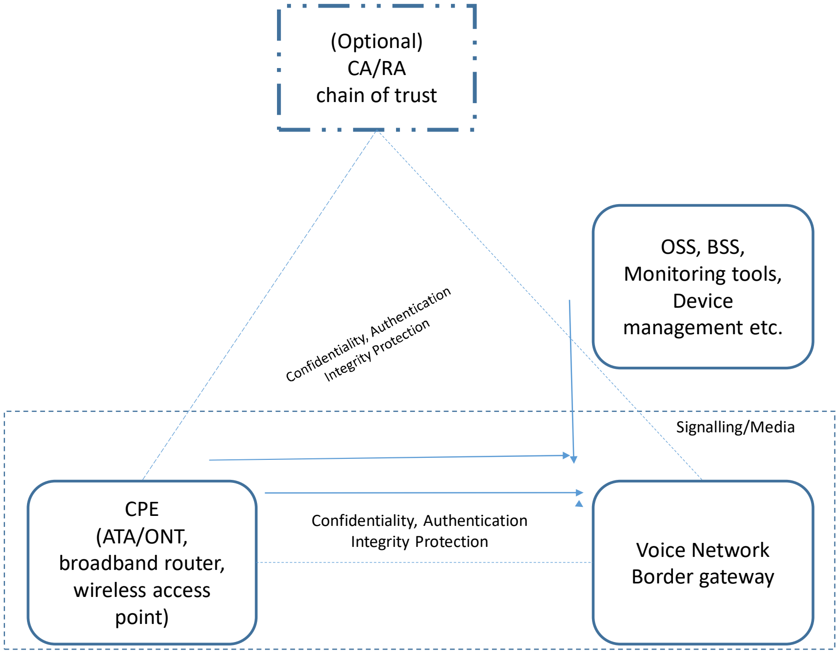
1. SIP aware telephony endpoint used by caller and callee. [Supplied and managed by owning ITSP]
2. Fixed line broadband home router interfacing with ISP/ITSP.
3. Telephony platforms of the IPT Communication Provider network.

Within the scope of the document, it is assumed the telephony instrument connecting to the SIP endpoint would be a DECT instrument or a traditional corded POTS instrument. Also, the SIP aware endpoint shall be a standalone or broadband router with built-in ATA.

Networking technology relating to NFV or SD-WAN are recognised as being potential building blocks of an end to end IP telephony service but beyond the scope of this document. See normative reference [i13]

The caller or callee could be served by a single Communication Provider or could be served by two separate Communication Providers where the IP transport is provided by one CP but telephony service is provided by another CP.

Figure 2: Key interfaces



Application Layer	HTTPS, HTTP
Transport Layer	TCP, UDP
Network Layer	IP, IPSec
Data Link Layer	Ethernet
Physical Layer	Optical/electrical

Application Layer	SIP, RTP
Transport Layer	TCP, UDP, TLSv1.3
Network Layer	IP, IPSec
Data Link Layer	Ethernet
Physical Layer	Optical/electrical

The key interfaces involved are as follows:

Client End	CP End	Interface	Purpose
CPE	Voice Network Border Gateway (Voice SBC)	SIP, RTP TLS\SIP, SRTP	Control plane and User Plane
CPE	Device Management Server	TR69, HTTPS XML type exchange	Configuration management and Provisioning
CPE	O&M Systems	SNMP alarm traps	Operations & Support Fault Reporting and Monitoring

4.2.1 All IPT CPE

There are two typical implementations for the end customers to connect telephone instruments to an IP voice service. One is to use a separate Analogue Telephony Adaptor (ATA) that takes a LAN connection from the customer home broadband router and provides a means to connect a phone to this additional external device. The alternative is using a device where the ATA is integrated within the home broadband router and a telephony port is presented on this integrated unit.

4.2.2 CAT-iq

CAT-iq is a standards-based technology owned by the DECT Forum. Within this forum there are certification processes to cover the CAT-iq certification process in addition to DECT Security certification process. See Informative reference [i12].

5 Threats to the All IP Service

5.1 Threats

A threat is the intent to do harm in some way such as destroy something or weaken or deprive someone of something. This, in the IP domain, is typically done by exploiting a vulnerability, such as poorly written code or a defect within the code.

For more detail and references see section 9.3 of this document.

The information and telephony being transported over IP has a potential of being compromised in various ways resulting in potential loss of secrecy, integrity, authorised access to the network and unlawful misuse of the data. These may result in financial, reputational, legal and regulatory punitive measures and loss of confidence of shareholders and customers.

For a PSTN replacement using an all IP Telephony service, a key risk to the service is loss of revenue and or reputational damage through unauthorised use of the service.

Key threats to IPT are;

1. Fraud
2. Misuse of service
3. Denial of service

To invoke the above threats, enabling actions such as “Man in the middle actions” or “Reconnaissance actions” may be invoked.
“Man in the Middle actions” are actions which allow an attacker to act as a look-alike end point or platform to capture information. This information could be used to impersonate or adversely affect the customer’s service or use the service fraudulently.
“Reconnaissance actions” are those actions which allow the configuration or data to be acquired for future use to potentially attack the service.

5.1.1 Fraud

Fraud is the ordering or use of a service with no intent to pay. This results in either the Communication Provider losing revenue, or a different subscriber being charged for the service (if, for example the fraudster is using the subscriber’s credentials).

5.1.2 Misuse of Service

The Misuse of service is any action performed against the service to adversely affect the IPT Customer or IPT CP. This could be instigated by an unauthorised user either hacking a legitimate user’s access or attempting to harvest and use information that would be used to misuse services.

5.1.3 Denial of Service

Denial of Service (DoS) is an (often malicious) attempt to make a host(s) or network resources unavailable to genuine users temporarily or indefinitely by disrupting the intended functioning of the system(s), for example by flooding it with access/connection requests.

Typically, DoS attacks take one of these forms;

1. Targeted DoS attacks to a platform which could include TCP/IP, DNS and SIP attacks.
2. Distributed DoS (DDoS) attacks, where multiple endpoints are used to produce an advanced form of service denial.

To protect against DoS there is a need to ensure that only “Authenticated” devices should make calls using IPT. Depending on implemented architecture, this should either be explicit, (e.g. end device must be explicitly registered) or some method of implicit authentication (e.g. end device has been previously authenticated).

This is particularly important for the 999 service. To maintain availability (for individual and the whole service) there is a need to balance customer availability against denial of service potential to the emergency service.

5.1.4 Nuisance and Scam calls

The number of nuisance and scam calls to customers on Voice platforms has increased significantly over recent times. A number of initiatives are underway to build trust in telephone numbers.

The following reference documents apply -

1. General Licence Conditions (General Condition C6 requires communications providers to provide CLI facilities) [8]
2. Code of Practice Ofcom - Guidance on the provision of Calling Line Identification facilities and other related services [9]
3. ND1016 [10]
4. ND1439 [11]

For All-IPT telephony the issue of nuisance and scam calls to IPT customers is outside the scope of this ND best practice.

5.2 Mitigations and controls

The solutions to mitigate the associated threats to a VOIP service are significantly different to that of a traditional fixed line telephony service where, historically, all the control traffic was isolated within the telephone exchange perimeter.
VOIP may expose control traffic, such as SIP, to the customer endpoint demarcation. This creates far bigger challenges for security of the IPT service and presents a larger attack surface.

Typical mitigations would consist of: -

1. Identity and credit checks as part of the ordering process.
2. Access control on service portals to restrict users to only access information to which they are entitled.
3. Use of user identification, authentication and authorisation controls; for example, by logging into the CP’s website with username and password.
4. Access control on services accessed through the telephone handset, such as for voicemail and other supplementary services, for example, by enforcing the user to enter a PIN to access the service.

5. Design considerations to ensure that only allocated and identified CPE/broadband lines can be used by the IPT to provide a specific customer service, for example, by binding authorised CPE to the broadband line ID and possibly the IP address, in order to authenticate IPT service. This would provide confidence in location information for 999 service on IPT.
6. Use of SIP authentication between IPT ATA and IPT Platform, with robust mechanisms in place to prevent disclosure of the associated SIP credentials.

Consideration **should** also be given to implementing the following protections, namely:

- On CP Service Portals:
  - Single sign-on between multiple areas of the service portal, so that the user doesn't have to enter a different password for each area of the service portal,
  - Two factor authentication, for example where user receives a unique PIN code to his mobile number after putting password to login.
  - Bilateral verification, where the user is able to verify that the portal is a genuine web portal and the Communication Provider **should** be able to verify the identity of the user logged in.

- On CP Platforms:
  - Configuration of the IPT platform in accordance with CP's security policy, and with IPT platform vendor's recommendations.
  - Network traffic /Signalling/ and Platform monitoring
  - Use of intrusion prevention mechanisms such as Firewalls, SBCs or IDS, and consider judicious use of Intrusion Prevention Systems.

Consideration should also be given to the way internal access of the IPT platform and associated OSS/BSS is managed, such as;

- Implement suitable OSS/BSS configuration and implementation to prevent misuse of key services, for example Call diversion, premium numbers misuse etc. As a minimum all usage **should** be monitored and targeted preventative methods employed where possible.

- When designing the service, attention should be given to the amount of detail that is provided in terms of physical labelling and potential for connecting un-authorised devices. The same principles apply with the underlying operating system and application to minimise the amount of detail disclosed when the device is accessed.

- Controls should be put around any areas where mitigation still shows a higher residual risk than the business would want to tolerate. It is important that these controls are detailed and time bound for review with clear accountability.

5.3 Threat Sources and actors

Large organisations will have their own trusted resources for intelligence which is beyond the scope of this document. See Section 9.3 for information and references associated with the fraud aspects.

6 IPT Service Security Dependencies

The delivery of the IPT service has several underlying dependencies and associated criteria. These include

1. Delivery of customer broadband service including DNS.
2. Design and implementation of customer CPE.
3. Requirements for delivering the 999 service

6.1 DNS

Traditionally, deployment and use of DNS has been ubiquitous in the World Wide Web. The evolution of telephony and overall communication network-based services delivery has resulted into incorporation of DNS related technologies in IPT communication services.

Implementations vary largely but use of FQDN (Fully Qualified Domain Name) in SIP registration and telephony sessions require some form of name resolution by the name server at communication provider end. This is achieved either by dynamic exchange of DNS query/response or by static mapping in local host files.

Such variations mandate consideration of securing DNS infrastructure and its associated communication. DNSSEC, briefly described below, is one of many means, however complex, to achieve this end goal.

6.1.2 Secure DNS (DNSSEC)

Secure DNS could be considered if there are concerns around the integrity of DNS communication within the IPT solution. Typically, DNS can be susceptible to a range of exploits such as forged DNS updates, unauthorised zone transfer, cache poisoning and man in the middle attacks.
Secure DNS can help protect against this to ensure a valid source of DNS response that has not been tampered with in transit and adds a digital signature to DNS responses using a chain of trust to validate responses.
Integrating Secure DNS into an existing solution may be more complex than taking a green field approach but Secure DNS is more complex to implement and operate than traditional DNS deployment and is why it is not widely adopted in industry. See informative reference [i14]

6.2 All-IP and Emergency calls

The owning CP has to meet the current General Conditions of Entitlement (specifically Annex A3 of Annex 14 (2017)) which refers to CPs responsibilities with respect to safeguarding customer access to the Emergency Services

7 IP Voice Security Areas/Implementation

For any specific implementation there will be a defined architecture. From this there will be several specific areas that will need to be addressed;

1. IPT Platform Security.
2. CPE to IPT network transport design, including CPE authentication and IPT dependencies such as DNS, broadband network etc.
3. CPE Security implementation.
4. Signalling Security, including SIP authentication.
5. Media Security.

7.1 IPT Platform Security

The aim of security is to reduce exploitable risk to the Platform/Service/Product and mitigate the impacts of any incidents. This is achieved by a circular approach, i.e. identify risk, prevent (by putting in place mitigations or design enhancements), detect security incidents and react in a timely and appropriate manner to security events (ideally pro-actively).

The following security considerations should be made:

- A SIP aware boundary device (such as a Session Border Controller [SBC]) is strongly recommended to provide the following features;
    - Act as a back-to-back user agent (B2BUA)
    - Provide network topology hiding
    - Protect the network and other devices from:
        - Malicious attacks such as a denial-of-service attack (DoS) or distributed DoS
        - Fraud via rogue media streams
        - Malformed packet protection
    - QoS policy of a network and prioritization of flows
    - Control of media flows

- The SBC **should** be configured to only allow IPT service required protocol signalling from the trusted All IPT CPE endpoint. All other application ports should be administratively disabled.

- Secure generation, management, distribution and storage of authentication credentials and encryption keys for the All-IPT service. Examples of this include, if service suite uses any or all of TLS, IPsec and SIP digest authentication methods, then this will require security procedures for handling MD5 credentials, X509 certificates and encryption key pairs on the IPT Platform and on the CPE.

- The IPT platform **should** be accessible for user plane and control plane traffic by exposing only a limited amount of public facing interfaces whose identities are embedded into the CPE firmware configuration, such that it is not accessible for the end user to read or amend.

7.2 CPE Security Implementation

7.2.1 Managing the CPE

All IPT CPE (as a consequence of its use in association with multiple services) needs to be securely managed, usually over the customer broadband.

7.2.1 CPE Security

As the IPT service is of a fixed (rather than a Nomadic) VoIP type, care **may** need to be taken in order to ensure that Home Routers supporting the All IPT service are connected to a data line allocated to a customer's specific voice identity e.g. a geographic E.164 number. Such protection **may** be afforded through an authentication server, so ensuring that a hub is indeed connected to an appropriate data (e.g. Broadband) connection.

CPE security will be dependent on the chosen, implemented IPT architecture. However, the following areas should be considered as part of the CPE design.

- Security software Design including
  - Security of log files stored on the CPE.
  - Security of the boot process of the CPE.
- Prevent being able to tap into the service from the copper line/optical line side of the CPE**.**
- Prevent DOS attack towards the Communication Provider infrastructure (SIP or Media).
- Validation and prevention of spoofing/manipulation of SIP messages can be

7.3 CPE to IPT network transport design

7.3.1 CPE security assessment

The CPE architecture will be implementation dependent however NICC recommend some areas that would benefit from Penetration testing that should give insight to security weaknesses;

- Testing against IPT enabled CPE used by the IPT service (This could be ATA or CAT-iq enabled equipment and associated CP supplied home router/hub)
  Tests should include-
  - Security of log files stored on the CPE.
  - Security of the boot process of the CPE.
- Testing using non-Digital voice enabled CPE and third-party CPE to determine if it is possible to attack the IPT service platforms.
- Testing CAT-iq specific for handset spoofing and/or Man in the Middle attack.
- Un-intended access to any control or protected data from the customer LAN side interfaces
- Any ability to tap into the service from the copper line/optical line side of the CPE**.**
- Ability to launch a DOS attack towards the Communication Provider infrastructure (SIP or Media).
- Validate if SIP messages can be spoofed or manipulated (E.g. (fake calls/ bye requests/not available response).

Many security issues should be prevented within the integration testing process and mitigated /removed at an early stage of the development life cycle.

7.4 IPT Signalling Security

This area again will be architecture dependent. Implementations will make use of transport network design and device authentication such as;

- Transport security using IPSEC/PKI or TLS.
- CPE authentication (SIP authentication or SIM based technology).

For more details see section 8.

7.5 IPT Media Security

Again, this is architecture dependent but consideration should be made to implement Media security protections, for example use of SRTP.

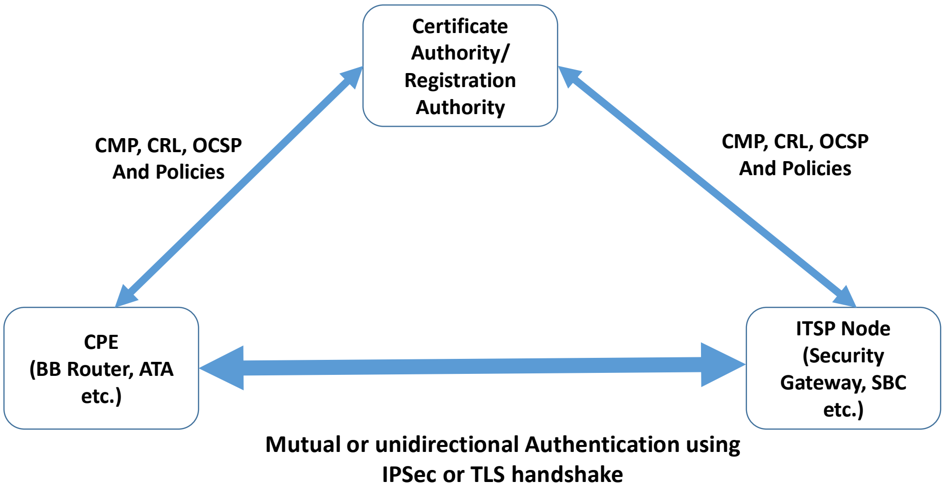
8 IP Voice Cryptographic Security

To ensure the confidentiality, integrity and authentication of the information on the communication networks, the use of asymmetric cryptography, symmetric cryptography and hashing functions are recommended.
It is up to the Communication Provider (CP) to adopt the scale of implementation in their network, depending on the CP implementation of technology and CP security policies, standards and procedures.
This Guidelines ND describes the factors to consider whilst architecting the solution, with the aim to make IPT as secure as practicable.

It **should** be noted that the use of encryption techniques by the Communication Providers, such as secure SIP and SRTP, will result in the loss of visibility of the traffic for diagnostic purposes unless the encryption is removed at the interface where lawful interception is required, and operational diagnostics data are gathered.

8.1 Use of PKI

Figure 3: Certificate Management


Certificate Authority/ Registration Authority
CMP, CRL, OCSP And Policies
CMP, CRL, OCSP And Policies
CPE (BB Router, ATA etc.)
ITSP Node (Security Gateway, SBC etc.)
Mutual or unidirectional Authentication using IPSec or TLS handshake

8.1.1 Use of Public Key Infrastructure

It is recommended to use Public Key Infrastructure using X.509 (PKIX) in the communication networks for embedding the three security principles (confidentiality, integrity and authentication) into the overall solution architecture.
The PKI is a framework that encompasses hardware, software, people, processes and procedures involved in the security apparatus deployed within the CP. It could be a logical function running in software or could be dedicated high density hardware based separate multi-tier distributed

infrastructure that is responsible for ensuring security for the services offered by the communication provider.
It uses asymmetric (because use of two uniquely distinct pairs of keys) cryptographic algorithms to authenticate client- server entities participating in application layer protocol handshake to establish a secure transport link for the application layer in TCP/IP protocol suite.

It is recommended to use, as a minimum, the following fundamental components of the PKI model described in these subsections:

8.1.2 CA Certificate Authority

It is recommended for the CA to be a central management node in the model responsible for the following:

- Generate, issue, distribute public key certificates.
- Distribute CA certificates.
- Generate and publish certificate status information
- Provides a mechanism to a requesting party to request revocation
- Revoke public key certificates.
- Identify and authenticate subscribers.
- Receive a public key from the subscriber for generating a certificate for the subscriber.
- Verify that subscriber has a corresponding private key for the public key submitted.

It is highly recommended (mainly for multinational CPs), given the sensitive role of the CA, that the multi-tiered CA hierarchy is deployed, dispersed through regional distributed architecture. This approach requires designating one CA as a root CA that signs the certificates of its subordinate CA, which could well be a regional CA. Then the regional/subordinate CA is delegated responsibility to sign the certificates for the issuing CA. Therefore, the model results into at least three levels of the CA hierarchy. The issuing CA is then responsible for signing the certificates for the networking elements participating in secure transport link establishment. E.g. User Agents (SBC, SIP enabled ATA etc.).

An example of such deployment model could be where the root CA remains offline (not networked in any form) and signs certificate request for the subordinate CA – one in north of the country, one in midlands and one in the south of the country.

This architecture model allows highest level of reliability, scalability, security and the load distribution among issuing CA. If any of the issuing CA is to be compromised or if the keys are to be compromised, having a central offline root CA and its subordinate CA means new key pairs and signed certificates for the compromised issuing CA could be issued without compromising the whole security apparatus of the organisation. It also limits the number of end entities that could be compromised when any one particular issuing CA is compromised.

8.1.3 CRL- Certificate Revocation List database

Various deployment models exist but considerations **should** be made, at the least, by deploying the CRL database in the DMZ of the network on a SFTP server or LDAP server.

8.1.4 OCSP- Online Certificate Status Protocol

This is an optional supplement to CRLs as the OCSP checks the revocation status of the certificate. The advantage of using OCSP in parallel to CRLs is having more timely revocation information than is possible with CRLs and additional status information. However, it is noted that the proposal requires an OCSP requestor and a responder in the overall PKI architecture as without OCSP responder responding to the OCSP requestor, the certificate is not accepted as a valid certificate by the OCSP requestor.

8.1.5 X509 Certificate

The latest version of X.509 certificate should be used (currently v3). X509- is the ITU-T standardised format of the certificate file

It is recommended to, at least, define the fields such as issuer common name, subject common name, certificate validity dates, subject alt name and applicable extensions including but not limited to basic constraints and the key usage.

8.1.6 Use of private/public key pair using RSA and DH key exchange algorithms Certificate

It is recommended to use higher key strengths 2048 bits or 4096 bits for better security. Also, with evolution of security measures, the equipment support for legacy 1024 bits may be limited.

Use of strong hashing functions is recommended such as SHA2 or AEAD (Authenticated Encryption Additional Data). SHA- 1, SHA-2 for digital signatures and MD5 should be avoided.

8.2 Recommended ‘Automated’ approach

The preferred approach to secure a solution by design is to automate the key functions such as key pair generation and certificate revocation/issue to minimise the risk of human factor. It is therefore recommended to make use of online management protocols such as Certificate Management Protocol (CMPv2) that provides interactions between PKI components recommended above.

Also, it is highly recommended to define X.509 certificates extensions that cover extension for the Certificate Revocation List (CRL) where the depository of the certificates is maintained. The OCSP (Online Certificate Security Protocol) could be used as a supplement to check the status of the certificate. It’s often the case that the CA/RA and CRL database are all maintained within the CP’s network within the boundaries of the trust domain.

The CPE involved in setting up a communication channel **should** first secure the link with the CA using Transport Layer Security (TLS) handshake. It is therefore recommended to make use of two separate key pairs; one pair generated for the communication with the peer node within the ITSP and the other pair is a burned-in during the manufacturing to be used for securing the transport link with the CA itself.

8.3 Alternative ‘Manual’ approach

In an alternate approach, the certificates could be self-signed certificates without use of CA hierarchy. The certificates and the key pair could also be sourced from an external CA in deployment scenario

where in-house PKI apparatus does not exist. However, such adoptions involve increased risk during X509 PKCS format certificate and encryption key PEM file transfers by operations individuals.
It also adds operational overhead for proactively manually checking certificate expiry, handling of the key pairs and certificates through emails or SFTP servers, reacting to the expired certificates by reissuing them and hence the time lag introduced and regenerating key pairs in cases when key pairs are compromised. All these factors result into inefficiencies and allow backdoors/holes in security procedures that are prone to the short window of exploiting the vulnerability.

8.4 Use of IPSec

For an All IPT Fully Integrated Architecture deployment models, recommendation is to use IPSec to encrypt all traffic profiles within the secure tunnel, with or without TLS for individual application layer protocols within the tunnel. However, this depends greatly on the overall solution architecture for voice and IP network within the CP. The suitability of using either the IPSec in the tunnel mode or transport mode, use of AH (Authentication Header) based IPSec or ESP (Encapsulated Security Payload) based IPSec are to be assessed on per solution basis, each having its own benefits and suitability. The IPSec secure tunnel is established once the four-way handshake is completed. The recommended practice for setting up IPSec is using X.509 certificates if PKI infrastructure as detailed above is deployed.
Alternatively use of pre-shared AES key of strengths 128bits, 192 bits or 256 bits also ensures equivalent level of security.

8.5 Use of TLS

For an All IPT Hybrid Architecture, use will be made of TLS on a per application basis namely the following interface types will be individually secured;

1. O&M interfaces between CPE and ITSP
2. Voice signalling interfaces between CPE and ITSP telephony gateways

At the time of writing this ND, it is assumed that SIP URI would be used for SIP PDU while implementing the TLS for securing the transport for SIP based telephony. However, use of SIPS URI scheme could also be considered albeit considerations should be made with the peer telephony nodes for ensuring interoperability.

8.6 Use of SRTP

If the TLS is used for securing SIP signalling with the voice platform, then use of secure RTP also may be considered. The encryption keys for securing the RTP are negotiated during SDP offer/answer exchange using SDES ‘crypto’ media attribute containing the mandatory crypto suite for authentication, encryption and integrity.
The use of SRTP is optional, however if implemented, then it is recommended to secure the SIP signalling using the TLS so the SIP PDU containing the master key, session key and salt value for establishing secure RTP are not in plain text. The use of SRTP also could consider for use of other key exchange protocols such as ZRTP, MIKEY and DTLS-SRTP. As the implementations often use RTCP alongside RTP, it is recommended to give considerations for the use of SRTCP, however implementation is optional. It is recommended not to fall-back to RTP in deployment scenario where risk assessment mandates use of SRTP for all calls. If the peer node cannot support SRTP, then alternate secure delivery methods such as private peering or use of IPSec tunnels could be considered.

9 Generic Security Controls

9.1 Access Controls

All Platform access for configuration, operation and maintenance shall

a. Have processes and procedures to control and allocate access for use.
b. Allow appropriate roles and capabilities to be clearly defined and managed.
c. Maintain a documented detail of access list functions deployed.

Where appropriate use shall be made of two factor authentication.

9.2 Good Practice information and guides

The following references are designed by and sourced from the industry supporting the technology and devices in scope of this NICC Standard. They are based on current best knowledge and experience.

The references listed in this section were correct at the time of publication.

For any further information about the documents referred to in this section, please contact the relevant document owner.

Additional guidance can be found in ND1438. See normative reference [6]

9.2.1 Cyber Essentials Scheme

Cyber Essentials is a government Scheme which is supported by industry. It enables organisations of all sizes to be tested against a set of criteria to ensure they have good basic cyber hygiene in place. A description for the Scheme can be found here –

- Cyber Essentials Scheme: overview. See Informative reference [i6]
- Cyber Essentials self- help information. See Informative reference [i7]

9.2.2 NCSC 10 Steps to Cyber Security.

Guidance on how organisations can protect themselves in cyberspace, including the 10 steps to Cyber security can be found at the NCSC website. See Informative reference [i1]

9.2.3 Fraud Mitigation Documentation

The FCS has produced a standard for mitigating fraud. The FCS Fraud Mitigation Standards -
See normative reference [4]

The FCS also produces a Telephone Security Checklist –
See normative reference [5]

The Communications Crime Strategy Group, which sets the strategic crime agenda for the industry members it represents -
See informative reference [i8]

The UK's national fraud and cybercrime reporting centre
See informative reference [i9]

UK Cross-sector fraud sharing organisation
See informative reference [i10]

Association of Certified Fraud Examiners
See informative reference [i11]

9.3 Threat intelligence and Threat actor classification

Threat intelligence is a large and complex area that cannot be well described within the scope of this document and will differ depending on the type of organisation.
Simple definitions can be:

- Evidence-based interpretation of data, collected on or against the identities, goals, motives and targets of malicious actors;
- Information that provide relevant and sufficient understanding for mitigating a harmful event.
- The process of analysing data creating contextualised knowledge to mitigate a threat. A threat is an event potential to cause harm.

The maturity of being able to collect the intelligence and build this into a threat model is still relatively immature in many technology areas. However, there are many threat intelligence sharing initiatives, one example being the Cyber Security Information Sharing Partnership (CiSP), a joint industry and government set up to exchange cyber threat information in real time in a secure, confidential and dynamic environment. See informative reference [i15]

Below highlights some basic threat terminology that is associated with IPT communications that can be used to reference out from to gain more detail. A recommended document is the Cyber Threat Intelligence Operations, from a CBEST Intelligence Led Testing. This documents a comprehensive list of threat intelligence resources, underlining the amount of information available on this subject. See informative reference [i16].

Threat actor classification is important. Hacking is a multibillion-pound industry for cyber criminals for commercial or political gains.

Actors typically fall into one of the following camps:

- External – Cyber Criminal
- External – State Sponsored
- External – Hacktivist
- Internal – Sys Admin, User, Manager, Executive.
- Partner - Third Party

Threat actor attributes can be built up by intelligence over time and give an insight to potential threats to your organisation.
These can include: -

- Relationship being Internal/external
- Geographic Operation
- Objective

- Motive
- Intent
- Typical industry target
- Tools and methods of attack
- Asset types typically targeted

Incidents will have at least one and usually more actions instigated by a threat actor. These typically fall into the following categories:

- Social Engineering- people hacking
- Misconfiguration – errors, malfunctions, omissions
- Hacking – unauthorised access
- Misuse – None approved actions
- Malware – Malicious scripts or code

9.4 Vulnerability Management

Vulnerability management assessment is essential in risk reduction. All devices **should** be subject to review and if vulnerabilities are found they **should** be recorded and prioritised for remediation. Some of this can be a paper exercise such as when reviewing tender details. Suitable tools **should** be used to probe for vulnerabilities open ports, etc. These tools should be run in normal design/test validation or with periodic (including penetration) testing.

In life systems **should** be scanned to ensure compliance and highlight misconfiguration or the insertion of none authorised code. This **should** be reviewed frequently and controls put in place to mitigate risk whilst change management requests flow through to remediating the vulnerabilities with patching or new code releases.

Any vulnerabilities that are not able to be addressed in the short term **should** be signed off as a risk by the system/platform owner to ensure accountability for risk in the organisation is managed. This can sometimes be the result of suppliers not having been able to fix the code for technical or commercial reasons.

Note: It is important to validate that suppliers recognise an organisation’s risk appetite and can deliver security patches and software updates that align with timeframes within the organisation’s vulnerability management processes. This can be problematic if not robustly managed.

9.5 Understand IPT assets

Every organisation **should** have an asset register and this is fundamental to protecting those assets. If assets are not known about, they cannot be monitored and protected.
Typical information recorded about an asset: -

- Asset ID
- Asset Description
- Ownership
- Location
- Categorisation (Low, Medium, High). Impact assessment against Confidentiality, Integrity and Availability (CIA).

Beyond this, there **should** also be a view on what assets are critical. It could be the case that some assets are shared between different platform solutions.

Having a robust inventory will ensure proactive measures are applied to all required assets and incident management will understand the assets they could respond to.

9.6 Business Impacts

The business impacts can be wide ranging from reputational damage through financial regulatory and legal impacts.

For financial impact typical areas of consideration would be: -

- Revenue loss resulting from down time.
- Staff required for post incident analysis.
- Infrastructure damage and the cost to implement new controls.
- Regulatory fines.
- Legal costs.
- Compensation costs.
- Loss of customer base.

9.7 Controls and organisational structure

Given the potential impact there is a compelling case for security to be embedded in all product development and design activities right through to deployment and in life operations.

9.7.1 Typical controls

Controls are used to mitigate impact of damaging system and network attacks. These controls are reviewed and tailored over time where their effectiveness can be assessed providing heighted maturity.

Some typical controls are shown below: -

- Hardware asset register.
- Software asset register.
- Hardening policies.
- Malware protection.
- Vulnerability assessments.
- Secure software development.
- Red Team exercises.
- Vendor conformance quality gates.
- Design test and conformance quality gates.
- Incident management.
- Business Continuity plans.
- Data Protection (Privacy by Design).
- User assess management.
- Proactive monitoring tools.

- Perimeter defences.
- Configuration management and validation.
- Data backup and recovery.
- Malware defences.
- Training and awareness.

9.7.2 Security Event Management

Often abbreviated to SIEM or Security Information and Event management. It usually integrates a number of technologies together to provide a holistic security view of the Platform. Examples of these could be events, alarms or logs generated from equipment as well as validation of correct configuration and live vulnerability scans. The aim of the event management is to provide centralised security event management where the alerting and other inputs are correlated. This allows operational teams to gain a dashboard view often in real time to make informed decisions and take corrective actions when appropriate. This helps to address managing a multitude of different technologies being bolted together that make up a service.

9.7.3 Change Control

The ability to assess the impact of changes and revision control to the platform is paramount. Often changes will need to be tested in a model environment to confirm compliance and maturity. It is also important that changes are fully understood and recorded, particularly when configuration changes are made.

Typical change control areas are: -

- New Hardware.
- New Software.
- New features.
- Capacity upgrades.
- Patching.
- Hardening.
- Reconfiguration.

Making sure that the platform can maintain control of all changes and these are fully socialised, documented and approved will reduce risk. A change management process allows this to be done formally.

9.7.4 Root Cause Analysis

This relates to vulnerability management as well. It is important to look at the cause of an event rather than just the symptoms. In a busy Operational environment this may not always be easy to achieve but it should be the objective rather than a short-term fix. More often this requires reaching out to other experts be that in the design and development space or the supplier. Organisations are likely to have a test environment where they can attempt to recreate a failure scenario. This can sometimes be time consuming and resource hungry but that needs to be balanced against the potential impact of another failure and the risk associated with that failure.

9.8 Response and Escalation

Security and business departments **should** be able to coordinate efforts and have a Security Response Plan (SRP) providing a methodical approach.

A good resource is NIS guidance collection on the EU directive on the security of Networks and Information Systems (known as the NIS Directive).
Around managing cyber security incidents and oversee the application of the Directive. This includes a National Cyber Security Strategy, a Computer Security Incident Response Team (CSIRT), and a national NIS competent authority, or competent authorities.
See Informative reference [i2].

9.9 Security Operations Centre SOC

The Security Operations Centre (SOC)

Key aims as taken from the NCSC website: -

- To detect and respond to threats, keeping the information held on systems and networks secure
- To increase resilience by learning about the changing threat landscape (both malicious and non-malicious, internal and external)
- To identify and address negligent or criminal behaviours
- To derive business intelligence about user behaviours in order to shape and prioritise the development of technologies.
- Depending on the nature of an organisation the choice is either to resource a SOC internally or reach out to a third party to implement the use as well as improvements to the security capabilities as the Platform evolves.
- There would also be the opportunity to raise defects that could be reviewed tracked and updated and aligned with findings raised within the test phases which could be reviewed periodically.

This is where change management plays a pivotal role on maintaining the integrity of the live Platform and robustly policing updates and the associated impacts throughout the Platform life.

When products are retired as end of sale, there **should** be contractual agreement between the organisation and the suppliers to ensure that high risk vulnerabilities can still be remediated and at what point this will no longer be possible. This is crucial to ensure that the Platform assurance levels are maintained and allows the Platform owners to plan for new technology to intercept key milestones.

9.10 Privacy

As taken from the Information Commissioners Office (ICO).

Privacy by Design is an approach to projects that promotes privacy and data protection compliance from the start. Unfortunately, these issues are often bolted on as an after-thought or ignored altogether. Privacy by Design is and by Default is a requirement of the General Data Protection Regulation and for high risk processing the ICO requires that a Privacy Impact Assessment is conducted. In certain circumstances if the data is particularly sensitive or high risk there may be a requirement to go to the Regulator in advance to discuss the purposes for processing. The ICO encourages organisations to ensure that privacy and data protection is a key consideration in the early stages of any project, and the throughout its lifecycle.

Taking a privacy by design approach is an essential tool in minimising privacy risks and building trust. Designing projects, processes, products or systems with privacy in mind at the outset can lead to significant benefits.

More detail on Privacy by Design can be obtained from the Information Commissioners Office. See Informative reference [i4].

In general terms the GDPR requires an organisation to do the following;

- Process personal information fairly and in accordance with applicable laws;
- Tell people (either directly or in our policies or notices) about how we will use their personal information;
- Only collect personal information when we need it for legitimate purposes, or legal reasons;
- Ensure that personal information is adequate, relevant and limited to what is necessary for the purpose for which we collect it;
- Kept accurate and up to date;
- Not keep personal information for longer than we need to;
- Keep personal information secure, and limit the people who can access it;
- Ensure that people know how to access their personal information and exercise their rights in relation to it;
- Ensure that any third parties we share personal information with take appropriate steps to protect it;
- Help our business customers to comply with any legal obligations they have in connection with any personal information that we process on their behalf.

More detail on Privacy by Design can be obtained from the Information Commissioners Office. See Informative reference [i5].
More information on Data protection including detail on conducting Data Protection Impact Assessments can be obtained from the Information Commissioners Office

History

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