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| Network Discovery and Selection |
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Abstract

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# Access Network Discovery and Selection

## Introduction

Access network discovery and selection describes the process of exploring the surrounding environment for detection of available access networks, followed by retrieval of information of each of the access network and finally the evaluation of the collected information in order to determine the most appropriate Node of Attachment to connect to.



Figure 1: Network discovery scenario with multiple SSs and CNSs

The process is usually executed either when a terminal performs its initial network entry after power on, or when a terminal lost or is going to lose its network connectivity and prepares for re-entry at another node of attachment, or when a terminal moves across an access network coverage area build by multiple node of attachments and the terminal relocates the link to another point of attachment to maintain best possible network connectivity during the move.

## Acronyms

* TE Terminal
* AN Access Network
* ANI Access Network Identifier
* NA Node of Attachment (e.g. AP)
* NAI Network Access Identifier
* SS Subscription Service
* SSI Subscription Service Identifier
* CNS Core Network Service
* CNSI Core Network Service Identifier
* EUI48 48-bit Extended Unique Identifier

## Roles and identifiers

* **User**
User represents the unique identity of a subscription. A user may have subscriptions with one or more subscription services. Unique subscription identifiers are created by an user name amended by the identity of the subscription service.
	+ ID of User: Subscription Identifier {NAI} + Subscription Name {String}
* **Terminal**
Terminal represents the physical device communicating with the core network service making use of an access network to establish the link. An unique identifiers is assigned to each of the terminals.
	+ ID of Terminal: {EUI48} or {EUI64}
* **Node of Attachment**
Node of attachment is the physical device at the edge of the access network creating the communication link to the terminal. Different NAs may have different capabilities.
	+ ID of Node of Attachment: {EUI48} or {EUI64}
* **Access Network**
Access network denotes the infrastructure consisting of one or more Nodes of Attachment and the related backhaul for providing the communication links between the nodes of attachment and one or more interfaces to connected core network services.
	+ ID of Access Network: ANI {EUI-48} + AN Name {String}
* **Subscription Service**
The subscription service is the entity establishing and maintaining user specific configuration and usage data. For security reasons the subscriptions service performs authentication of the corresponding terminal to ensure that usage and modification of user specific information is really caused by that user. Subscription service is commonly known as termination point of AAA.
	+ ID of Subscription Service: SSI {FQDN} + SS Name {String}
* **Core Network Service**
Core network service denotes the termination point of the user plane of a terminals. Multiple terminals may connect to the same core network service, but there may be several core network services available by an access network. Selection of the corresponding core network service may happen through authorization by the subscription service eventually amended by signaling from the terminal.
	+ ID of Core Network Service: CNS Identifier {??? - ffs} + CNS Name {String}

## Use Cases

Network discovery and selection is a prerequisite for a mobile terminal to establish and maintain network connectivity. A terminal initiates the network discovery and selection process for the following four reasons.

### Initial AN access

Initial AN access describes the case when a terminal is powered up or the network interface of the terminal is enabled and network connectivity initially does not exist without any prior knowledge about the availability of NAs available.

In this case the terminal usually performs a complete network discovery process to learn about all reachable NAs before executing the selection process from the root.

### AN re-entry

In this case the terminal has lost, or has not yet established network connectivity, but has some stored information about the last AN and the last NA, it was connected to. When selection policies prefer to re-establish connectivity to the last used AN, the terminal will try to execute an abbreviated NDS process by directly checking for the reachability of the last used NA. This process optimization makes in particular sense, when the access technology allows for active scanning, resulting in much faster network connectivity establishment.

When AN re-entry is not possible due to movement of the terminal completely out of the previously used coverage area, the terminal will perform an initial AN access process. Statistically however performing a AN re-entry trial before falling back to an initial AN access provides benefits, even when the worst case lasts longer than going strait into an initial AN access process.

### NA transition

The network discovery and selection process is initiated not only when network connectivity is missing but also when the terminal detects degradation on the network connectivity and endangers loss of connectivity. In this case the terminal provisionally searches for another NA offering better link conditions than the NA, to which it is currently connected.

When another NA of the same AN with better link conditions exists, the terminal will initiate a relocation of its ongoing network connectivity to the other NA while maintaining all upper layer connectivity states. Such a transition is commonly denoted as seamless handover.

### AN transition

When connectivity is in danger but seamless handover to another NA of the same AN is not possible, the terminal will carry through a discovery process for other ANs allowing for network connectivity. Usually the transition of ongoing connectivity to another AN will cause some disruption. How long connectivity is broken and whether upper level connection state can be maintained depends on the particular AN arrangements and implementations.

Usually interruption of connectivity during AN transition is much longer than during NA transition, but often much less severe than an initial AN access, which completely resets the whole communication stack.

## Functional requirements

The following requirements apply to the NDS procedures.

### Support for multiple access technologies

The NDS procedures SHOULD be able to handle within the same terminal various access technologies with different characteristics.

### Support for multiple different access networks supporting the same or different subscription services

The NDS procedures SHOULD to able to handle multiple different access networks based on the same or different access technologies serving the same or different subscription services.

The NDS procedures SHOULD support access networks served by multiple subscription providers.

### Support for multiple subscriptions on the same access technologies.

The NDS procedures SHOULD support multiple different subscriptions on the same access technology and/or the same access network as well as the usage of the same subscriptions on multiple different access technologies.

### Extensibility to support specific service requirements

The NDS procedures SHOULD support upper layer service specific attributes to enable different treatment of various access technologies and access networks depending on service requirements.

### Discovery of access network capabilities

The NDS procedures SHOULD NOT require establishing a-priori knowledge within the terminal about offered services of the existing access networks to perform the selection process.

The discovery procedures SHOULD allow retrieving service specific attributes.

## NDS specific attributes

Each of the entities involved in the NDS process comprises information elements, which are helpful or required when processing the NDS procedures. The following list provides examples of these information elements:

### User (Subscription)

* Access policies

### Access Network

* Supported Subscription Services
	+ LIST of Subscription Service IDs
	+ Cost, limitations per
* Supported Core Network Services
	+ LIST of Core Network Service IDs
* AN certificate
	+ CERTIFICATE
* Access Network Capabilities
	+ LIST of Link Layer capabilities
		- E.g. MTU, encryption, type of link, privacy
	+ RECORD of Link Layer performance parameters
		- E.g. supported service classes (Throughput up/down, delay, jitter)

### Subscription Service

* Supported Core Network Services
	+ LIST of Core Network Service IDs
* SP certificate
	+ CERTIFICATE

### Core Network Service

* Network Layer Capabilities
	+ LIST of Capabilities
		- E.g. IP versions, configuration, service discovery support
* Network Interface performance
	+ LIST of performance parameters
		- E.g. supported service classes (throughput up/down, delay, jitter)
* Offered application services
	+ LIST of application services
		- E.g. Internet, Voice, Printer, File service,

## NDS basic functions

### NA Discovery

NA discovery is the process in the terminal to retrieve the list of node of attachments, which can be reached via the physical medium. The discovery process is executed specific for a particular access technology, but a terminal comprising multiple different network interfaces may initiate and perform the process concurrently on all or on a subset of its network interfaces.

NA discovery can be either based on passive scanning or active scanning.

When performing a passive scan, the terminal turns on the receiver path of its network interface and ‘listens’ sequentially to all channels of the medium for messages indicating the existence of an active Node of Attachment. A complete scan may take quite some time depending on the periodicity of the indication messages and the number of channels. When speeded up by methods taking a-priori knowledge into account, the process of passive scanning may deliver specific or initial results earlier, but a complete scan always takes the time of periodicity of indication messages by number of channels. As passive scanning of radio does not emit any radio waves, the approach complies with any radio regulation framework.

Active scanning comprises a trigger send out by the terminal to initiate directed responses of node of attachments. By its nature active scanning is able to deliver results much faster but requires the terminal to transmit information frames on all channels of the network interface. Before sending out frames the terminal may be required to determine the regulatory domain where it is staying to ensure that transmissions comply to the applicable regulatory requirements.

NA discovery provides a list of node of attachments reachable by the terminal at its particular location.

### AN Detection

AN detection is the process to determine the identities and the capabilities of the access networks in reach. The terminal retrieves for each of the detected NAs the identity of the access network, to which the NA belongs.

Further information about capabilities of the detected ANs, like networking and performance parameters as well as supported subscription and core network services is derived either from broadcasted advertisement information, or a preconfigured local database, or from queries to remote databases. Remote databases may be either available over specific link procedures in the NAs or access networks, or even over network connectivity anywhere in the network, when some other connectivity exists during the AN detection process.

### SS Detection

SS detection is the process to determine the subscription services, which can be used for establishment of access to the detected ANs. The process creates a list of all available subscription services with information about the availability and preference of subscription services for each of the detected ANs.

The information about available subscription services is usually taken from the information collected during the AN detection, but there may be pre-stored information in the terminal together with the authentication credentials which provides the list of ANs to be used with the credential.

### CNS Detection

CNS detection is the process to retrieve the core network services, which are accessible through the detected access networks. The process establishes a list of all available core network services with information about the availability and preference of subscription services for each of the detected core network services.

The information about available core network services is usually taken from the information collected during the AN detection, but there is usually information available in the terminal as part of the subscription, which amends the information derived from the AN detection process.

### SS and CNS Selection

SS and CNS selection is a multi-dimensional selection process in the terminal making the best choice among the detected subscription services and core network services under the preferences, restrictions and limitations imposed by the available subscriptions. The selection process may perform a weighted evaluation of all available information down to interface parameters of the physical link to the point of attachment.

The selection process may be either hard-coded in the terminal as part of the operating software, or may be configurable by policies provisioned to the terminal.

## Detailed procedures

### First-time use of TE without subscription

The TE performs in step a)-c) a NDS procedure to find appropriate SS for creation of a new subscription. Online subscription set-up is performed in step d)-e).

1. TE runs NA Discovery and AN Detection and finds one or more available ANs.
2. TE runs SS Detection and CNS Detection, and finds available SSs and CNSs, and their associations with the ANs.
3. TE performs SS and CNS Selection and determines an AN and a SS based on defined preference criteria for running the subsequent online subscription set-up.
4. TE performs a special connection procedure with the selected AN for establishment of a subscription.
5. TE creates a trust relationship enabling network access authentication and authorization by the selected SS
6. TE acquires and stores the subscription of the selected SS

### Initial AN access

The TE is equipped with one or more subscriptions and attempts to establish a network connection after being switched on or moved into a coverage area.

1. TE runs NA Discovery and AN Detection and finds one or more available ANs.
2. TE runs SS Detection and CNS Detection, and finds available SSs and CNSs, and their associations with the ANs.
3. TE performs SS and CNS Selection according to the provisioned subscriptions and determines the preferred AN and SS for establishing network connectivity.
4. TE performs a network entry procedure towards the selected AN making use of the selected SS for authentication and authorization.

### NA transition

The TE discovers that the link to the current NA is getting weak and decides to pursue a transition to another NA of the same AN to maintain good link quality.

1. TE runs NA Discovery and finds one or more other NAs belonging to the same AN, to which the TE is currently connected to.
2. TE selects the NA for transition and performs a network entry procedure to new NA making use of the currently used subscription and SS for authentication and authorization of access.
If supported by access technology for faster handover, the TE may pre-establish the connectivity to the new NA through messaging with the AN via the current NA.
3. When connectivity to new NA is established, the TE turns down connection to previous NA.

In the case of failure, TE reverts to initial AN access.

### AN re-entry

The TE recently lost network connectivity and discovers by NA discovery that NAs of the same AN become accessible. To re-establish network connectivity with same SS and CNS the TE attempts to connect to NA of previously used AN.

1. TE runs NA Discovery and finds one or more other NAs belonging to the same AN, to which the TE was previously connected to.
2. TE selects the NA for connection establishment and performs a network entry procedure to the NA making use of the previously used subscription and SS for authentication and authorization of access.
3. Depending of duration of the connectivity break the TE may or may not pursue to resume the previous communication link to the CNS.

In case of failure, TE reverts to initial AN access.

### AN transition

The TE discovers that the link to the current NA is getting weak and decides to pursue a transition to the NA of another AN, which provides service to the same SS and CNS as currently used.

1. TE runs NA Discovery and AN Detection and finds that there is another AN with service to the same SS and CNS, which would provide better link quality.
2. TE decides to transition network connectivity to the other AN for continuation of service to the current SS and CNS.
3. TE selects the NA for transition and performs a network entry procedure to new NA making use of the currently used subscription and SS for authentication and authorization of access, and requesting connectivity to the currently used CNS.
4. Depending of the capabilities of the TE and the CNS the TE may or may not pursue to resume the communication link to the CNS.

In case of failure, TE reverts to initial AN access.

## Mapping to IEEE 802 technologies

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 802.3 | 802.11 | 802.15.? | 802.16 | 802.22 |
| Identifiers | TE | EUI-48 | EUI-48 | EUI-64 | EUI-48 | EUI-48 |
| NA | EUI-48 | EUI-48 | EUI-64 | EUI-48 | EUI-48 |
| ANI | ??? | EUI-48 | ??? | EUI-48 | EUI-48 |
| AN-name | 256 Char | 30 Char | ??? |  |  |
| Subscription Type | NAI | NAI/PSK | ???/PSK | NAI | NAI |
| Multiple SSs | Info | ANQP | - | ? | - |
| Discovery process | manual | passive, active | passive, active | passive | passive |

## Additional capabilities in IEEE 802 technologies

### IEEE 802.3

For further study.

### IEEE 802.11

IEEE 802.11 provides a number of functional enhancements to support more complex deployments:

* Access Network Query Protocol
* Pre-Association Discovery Protocol
* Network triggered NDS
E.g. Directed NA transition
* Online subscription establishment
E.g. Hotspot 2.0 ‘Online Sign Up’

### IEEE 802.15

For further study.

### IEEE 802.16

For further study

### IEEE 802.22

For further study