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Re:	Call for contributions	
Abstract	A protocol neutral approach to the development of Network Management standards	
Purpose	In light of the potential new PAR for Network Management and the task to create a Mobile MIB it is appropriate to review this previously accepted contribution.	
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An Architecture to Develop Network Management Standards

Abstract: IEEE802.16 networks are likely to be deployed by operators who already own and operate other (wireline and wireless) telecommunications networks. This results in a multi-access network or 'heterogeneous' network environments. In heterogeneous networks depending on the vendor, type of network, or level of software employed by an operator, different network management protocols could be employed. Therefore, the development of protocol neutral information for network management is the considered the best approach to specifying network management systems. While SNMP is still

utilized by some operators it is a protocol that has limited capabilities and lacks the granularity of some newer protocols, in some cases requires pre-configuration of the network entities. If a protocol neutral approach is used, the implementer of the network management system has the choice as to whether they desire to use SNMP, XML, SOAP, HTTP, CORBA, JAVA, etc. based on their particular need. Furthermore, the operator finds protocol neutral network management interfaces easier to integrate with their already existing networks. The benefit to both systems developers and standards writers is that as new protocols are added the protocol neutral part of the standard would not need to be updated and revised.

1. INTRODUCTION

Current operators with legacy as well as 802.16 access networks to manage will want a single, integrated management system. This integrated network management system is one of several steps required to establish viable business models for new services and capabilities. Management Interfaces in 2G/3G cellular systems have been developed to achieve this based on well-established TMN principles. Vendors and operators agreed that the most immediate opportunities and benefits for standardization existed on the interfaces between Network Managers (NM) and Element Managers (EM). This interface, labelled Itf-N for Network Management, has been the focus of initial standardization activities in cellular standards. Many perceive the initial deployments to be stand-alone data networks. One reality that has been identified by industry groups such as the Wireless Data Research Group is that "cell-phone companies could use WiMax to "backhaul" their wireless Internet service from a cell tower to a central office"[1]. Furthermore, the WiMax Forum has stated "in a metro area, it is desirable to install a sufficient number of base stations to cover an addressable market large enough to quickly recover the fixed infrastructure costs."[2] To achieve this, operators will face the issue of real-estate for base station and antenna or tower locations, the leading cost in any new wireless deployment. Since current wireless operators already have acquired and zoning approved location for base stations, it is very likely that they will be the first to market in metro areas. Current wireline operators are also likely to add a wireless tail to their data networks to enter the lucrative wireless business, that tail could be 802.16. When either or both of these scenarios occurs the current operator will desire a single system to manage the different networks. Figure 1 illustrates an example of the mixed or "heterogeneous" network that can result. The example in the Figure incorporates cellular voice, cellular data, broadcast, and IEEE 802 Wi-Fi and WiMax technologies. This single network management system is of several required steps to establish viable business models for new services and capabilities.

[1] From http://www.rockymountainnews.com/drmn/technology/article/0,1299,DRMN_49_3080674,00.html

[2] WiMax Forum, 'Business Case Models for Fixed Broadband Wireless Access based on WiMAX Technology and the 802.16 Standard', October 10, 2004 page 11

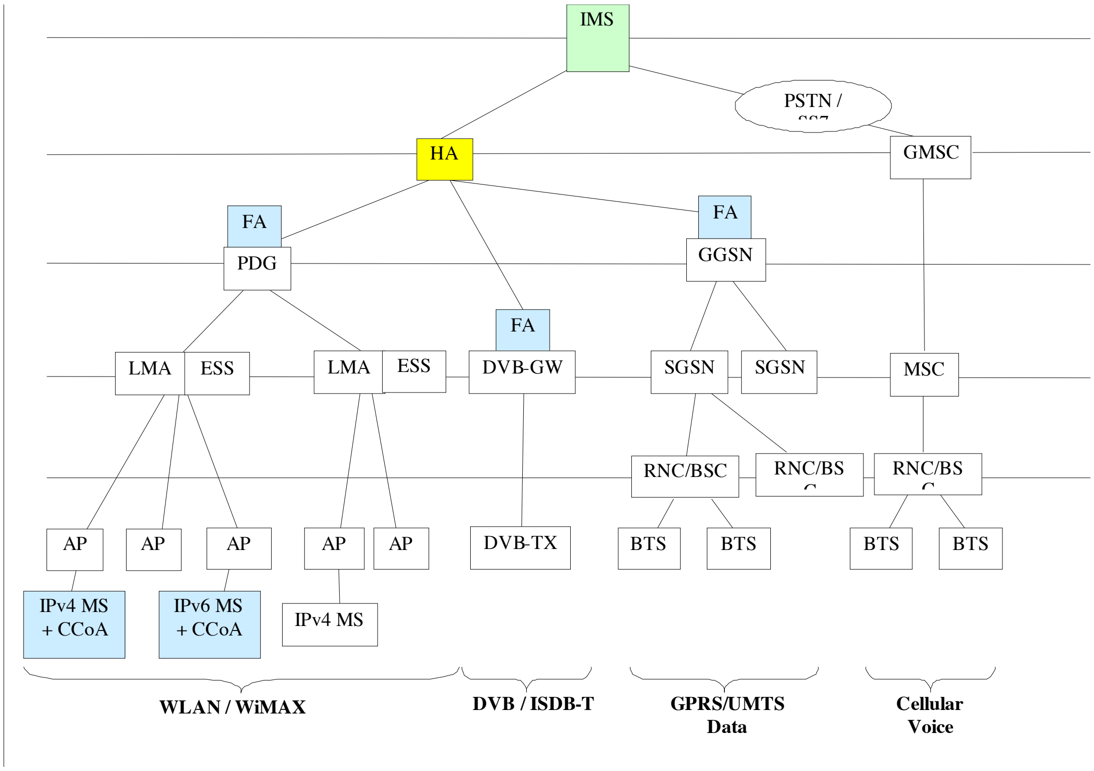

Figure 1. Example of a Heterogeneous Network

Management interfaces other than Itf-N have not been ignored by cellular SDOs but they are most likely out of the scope of 802.16NETMAN. These other interfaces have been labelled and categorized for you reference (see Figure 3 from [1]).
It is not the approach to define the complete management of all the technologies that might be used in the provision of a broadband wireless network. It is, however, the intention to identify and define what will be needed from the perspective of management. Figure 2. also does not imply any physical architecture in the routing of management information.

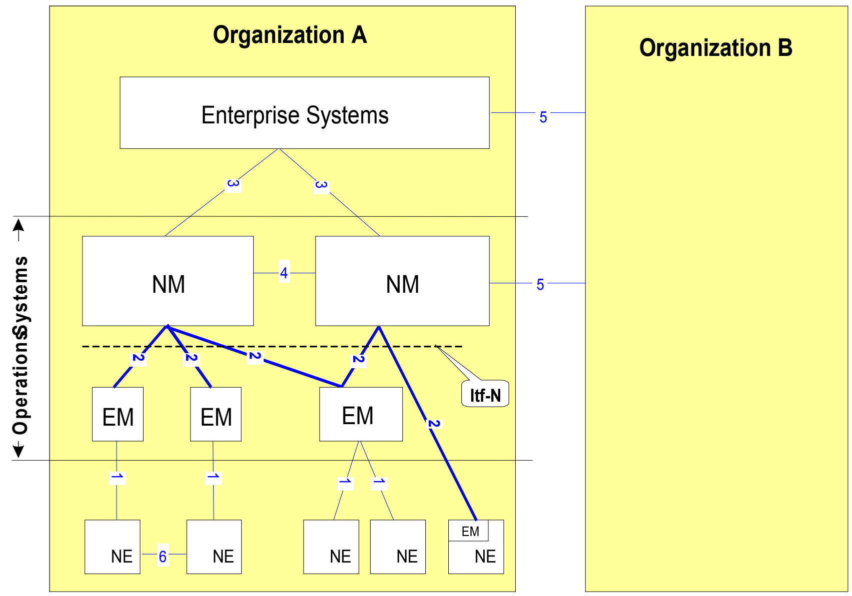

Figure 2: Management Interfaces and Information Architecture

A number of management interfaces in a broadband wireless network are identified in figure 2, namely:

1. between the Network Elements (NEs) and the Element Manager (EM) of a single broadband wireless network;
2. between the Element Manager (EM) and the Network Manager (NM) of a single broadband wireless network;

NOTE: In certain cases the Element Manager functionality may reside in the NE in which case this interface is directly from NE to Network Manager). These management interfaces are also given the reference name Itf-N.

3. between the Network Managers and the Enterprise Systems of a single broadband wireless network;
4. between the Network Managers (NMs) of a single broadband wireless network;
5. between Enterprise Systems & Network Managers of different broadband wireless network;
6. between Network Elements (NEs).

2. INTEGRATION REFERENCE POINTS (IRP)

For the purpose of Management Interface development an Interface Methodology known as Integration Reference Point (IRP) was developed to promote the wider adoption of standardized Management interfaces in telecommunication networks. The IRP methodology employs Protocol & Technology Neutral modeling methods as well as protocol specific solution sets to help achieve its goals. The Integration Reference Point is a methodology to aid a modular approach to the development of standards interfaces.

There are three cornerstones to the IRP approach:

1. Top-down, process-driven modeling approach
   The process begins with a requirements phase, the aim at this step is to provide

conceptual and use case definitions for a specific interface aspect as well as defining subsequent requirements for this IRP.

2. Technology-independent modeling
The second phase of the process is the development of a protocol independent model of the interface. This protocol independent model is specified in the IRP Information Service.

3. Standards-based technology-dependent modeling
The third phase of the process is to create one or more interface technology and protocol dependent models from the Information Service model. This is specified in the IRP Solution Set(s).

This modular three-step approach is depicted in figure 2**,** which also outlines some further details and advantages of the IRP approach.

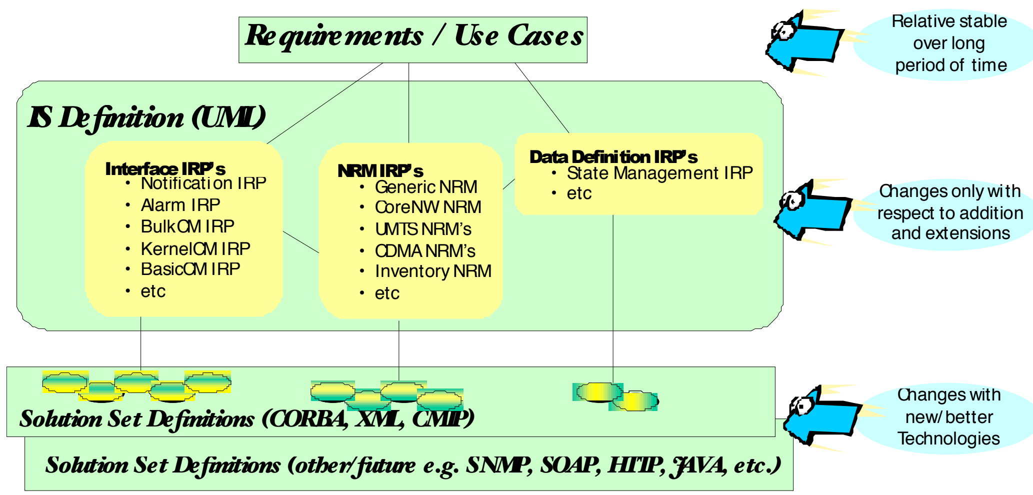

Figure 3: The IRP Approach

IRP Types: Figure 3 shows that at the Information Service modeling stage IRP's are categorized into one of three types:

Interface IRPs – These typically provide the definitions for IRP operations and notifications in a network agnostic manner. These enable independent development as well as reusable across the industry
NRM IRPs – providing the definitions for the Network Resources to be managed (commonly named "Network Resources IRPs"). These enable technology & vendor specific NRM extensions
Data Definition IRPs – provide data definitions applicable to specific management aspects to be managed via reusing available Interface IRPs and application to NRM IRPs as applicable. These enable a wide applicability, phased introduction capabilities & broad industry adoption.

IRP Advantages: *The modular aspect of the IRP approach divides the Interface specification into pieces that are:*

Relatively stable typically over long periods of time (the requirements).

Change more frequently but normally limited to additions and extensions of the Model (the information Service)
Change frequently as new and better interface technologies become available

IRP Development Principles: For the purpose of making the IRP-based management interfaces open for wide-spread adoption, the following principles were adopted:

NRM IRP Extendibility: through adoption of the *vs. DataContainer* construct as well as rule-based NRM Extensions
Interface IRP Flexibility: through NRM/Technology-neutrality as well as the flexible use of qualifiers (*mandatory, optional, visibility*) for operation, notifications and/or parameters

The development of IRP's is supported by the availability of an IRP IS Template, as well as an UML Repertoire, both defined in 32.102 [2].

3. IRP's FOR APPLICATION INTEGRATION

The IRP specifications and solution sets that have been developed or are under development by other SDOs cover a broad variety of Network and Service Management function, for example:

Alarm Management

Configuration Management

Performance Management

State Management

Inventory Management

Test Management

Log Management

Security Management

Subscription Management

Solutions sets currently available cover CORBA, XML and CMIP technologies, though expansion into for example SNMP or JAVA solution sets is also possible, these could be discussed and may develop subject to contribution and participation by interested organizations in 802.16NETMAN. See Annex A for a more complete listing and categorization.

On a macro view of a network the IRPs are developed to ensure interoperability between Product-Specific Applications (PSA) and the Network & System Management Processes of the Network Manager as shown conceptually in Figure 4. Although for the purposes of the work in 802.6NETMAN the focus would be on those parts of the process that focus on communication between the element manager and the network element. But this diagram shows why an approach that is interoperable to other management standards is important.

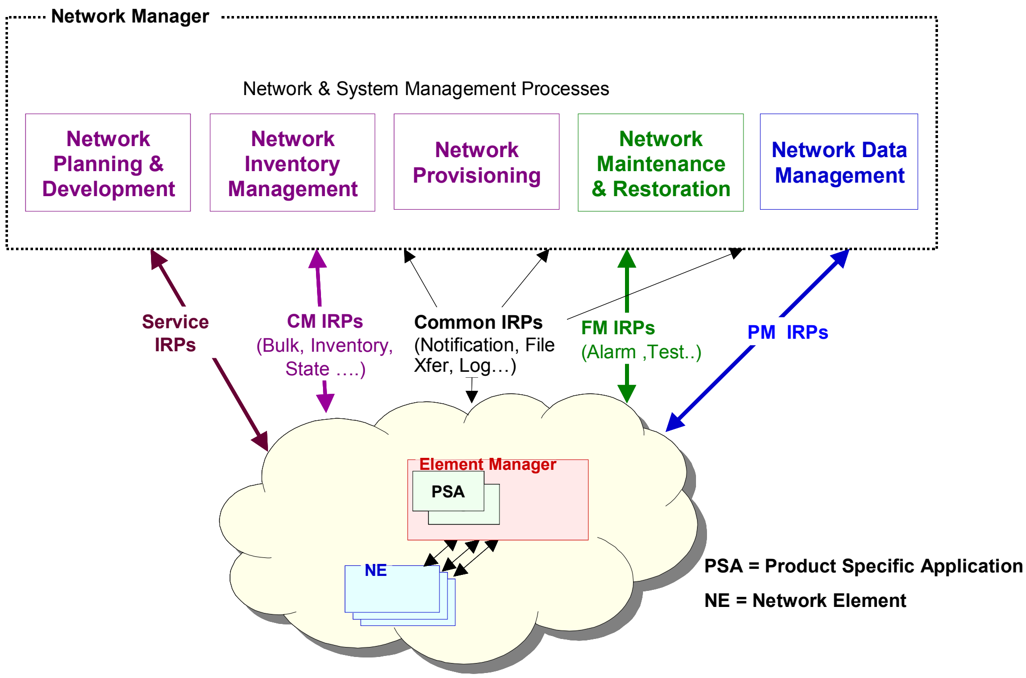

Figure 4: IRPs for Application Integration

4. AN INTERFACE IRP EXAMPLE

To more fully explain how the IRP works in application this section, by way of example and illustration, will show the how the IRP Methodology is applied to the Basic Configuration Management IRP. The Basic Configuration Management IRP is an Interface IRP and consists of a requirements part, an IS definition part and currently two Solution Sets, the CORBA SS and the CMIP SS.

Basic CM IRP IS: The IRP Information Service [3] specifies a number of protocol-independent operations that are needed by an IRPManager to retrieve CM information from an IRPAgent as well as to enable provisioning of network resources (note that related CM notifications are provided by another IRP, namely the Kernel CM IRP).

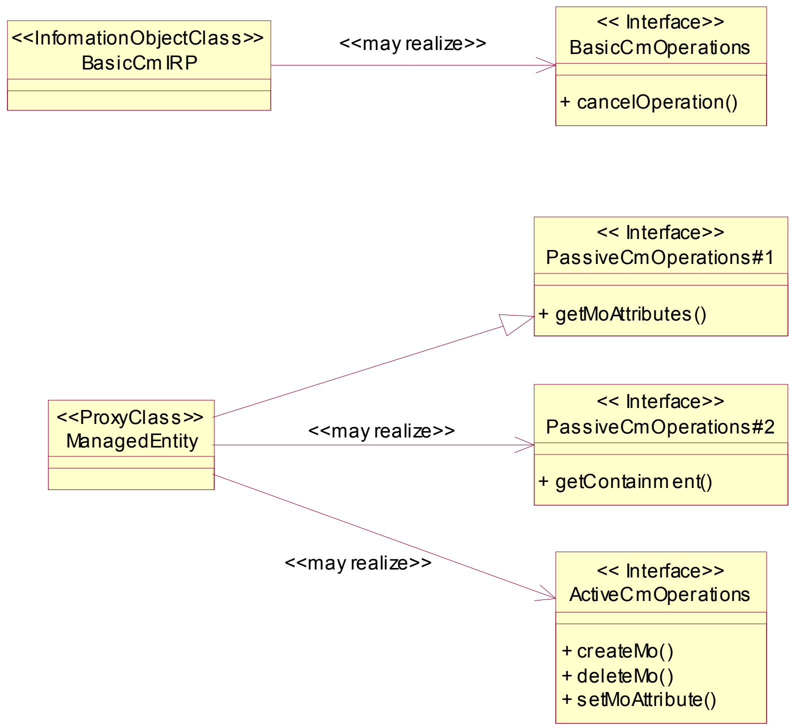

Figure 5: Basic CM IRP Operations

Figure 5 shows how the operations of the Basic Configuration Management IRP are modeled using UML notations as defined in the IRP UML Repertoire [2].
The information service specification goes on to detail each of the operations in detail in a tabular format listing input and output parameters, pre and post conditions and exceptions – based on the IRP IS Template defined in 32.102 [2].

The generic rules for CM IRP operations that are defined in IRP Information Service [3] are:

Rule 1: Each operation with at least one input parameter supports a pre-condition valid_input_parameter which indicates that all input parameters shall be valid with regards to their information type. Additionally, each such operation supports an exception operation_failed_invalid_input_parameter which is raised when pre-condition valid_input_parameter is false. The exception has the same entry and exit state.

Rule 2: Each operation with at least one optional input parameter supports a set of pre-conditions supported_optional_input_parameter_xxx where "xxx" is the name of the optional input parameter and the pre-condition indicates that the operation supports the named optional input parameter. Additionally, each such operation supports an exception operation_failed_unsupported_optional_input_parameter_xxx which is raised when (a) the pre-condition supported_optional_input_parameter_xxx is false and (b) the named optional input parameter is carrying information. The exception has the same entry and exit state.

Rule 3: Each operation shall support a generic exception operation_failed_internal_problem that is raised when an internal problem occurs and that the operation cannot be completed. The exception has the same entry and exit state.

Basic CM IRP SS: The Solution Sets will implement the Basic CM IRP IS operations by mapping them to standard operations that are applicable in the corresponding protocol environment.
A CMIP Solution Set will for instance map the operations to the more generic operations defined in CMIS, a CORBA Solution Set [4] will map the operations to applicable OMG/CORBA services, and a potential SNMP Solution Set would map the operations to applicable SNMP operations.

5. AN NRM IRP EXAMPLE

In this section we will by way of example and illustration of the IRP Methodology take a closer look at the Core Network NRM IRP. This IRP is an NRM IRP and consists, as all IRP's, of a requirements part, an IS definition part and currently two Solution Sets, the CORBA SS and the CMIP SS.

Core Network NRM IRP IS: The Basic CM Interface IRP described above specifies the operations needed by an IRPManager to retrieve information from an IRPAgent as well as to provision network resources. These operations are generic across all network types and so have been separated from the data model to which the operations are applied, however various Network Resource Models are required to model the information to be operated upon, A typical example of such a resource model specified by 3GPP SA5 is the Core Network (CN) Network Resource Model [5].

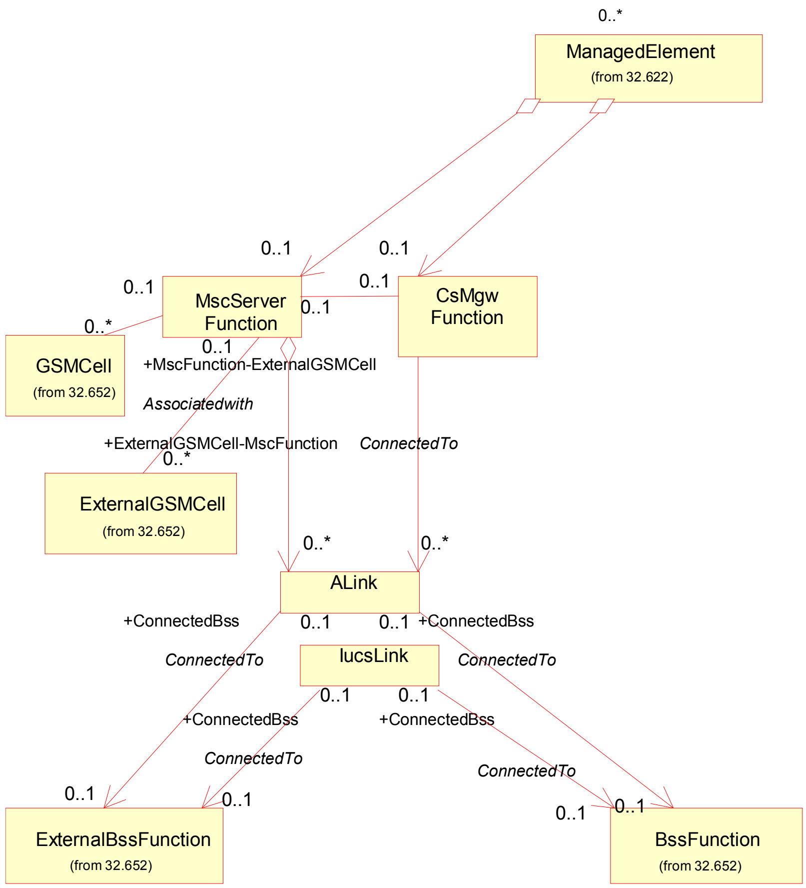

Figure 6: Part of the CN-GERAN NRM Containment/Naming and Association diagram

Figure 6 shows how the NRM again uses the IRP UML Repertoire to model the Core Network Entities in a protocol neutral fashion. The NRM specification goes on to detail attributes and notifications associated with each of the modeled entities.

6. 3GPP/3GPP2 CO-OPERATION

Figure 7: 3GPP/3GPP2 Co-operation

As described in paragraph 4 the IRP specifications are divided mainly into Interface and Network Resource Model IRPs. The Interface IRPs describe Management operations common across all networks, for example creating, deleting and changing data.

The Network Resource Model (NRM) on the other hand describes the specifics of the network to be managed. This modular approach has enabled other organizations such as 3GPP and 3GPP2 (Figure 6) to re-use the Interface IRP's, and even some of the high-level, network-technology independent NRM IRP's, and extending those models based on set rules to create 3GPP2 NRM IRP's for their specific needs.

The 802.16NETMAN group could also benefit from this approach by working with both groups to establish common and unique Interface IRP's that would be used by a particular NRM.

7. CONCLUSIONS

The IRP Interface Methodology give a standards developer, vendor, and operator through the modular, re-usable and protocol neutral aspects of specifications the ability to quickly change protocols when necessary, take technology and adopt into different deployed networks and have it interoperate seamlessly.
There has also been example on how SDOs may re-use extension of one specifications by another. These re-use advantages available by adopting the 3GPP IRP management interface development methodology. Once this is accomplished it is possible to use a protocol neutral approach to develop management standards an implementer of the network management systems will have the choice as to whether they desire to use SNMP, XML, SOAP, HTTP, CORBA, JAVA, etc. based on their particular need. The benefit to developers of both the systems and the standards are that as protocols are revised the information contained in a standard would not need to concurrently updated and revised.

REFERENCES

Note: All 3GPP specifications are available at www.3gpp.org

[1] 3GPP TS 32.101 Telecommunication management; Principles and high-level requirements

[2] 3GPP TS 32.102 Telecommunication management; Architecture

[3] 3GPP TS 32.602 Telecommunication management; Configuration Management (CM); Basic configuration management Integration Reference Point (IRP): information service

[4] 3GPP TS 32.603 Telecommunication management; Configuration Management (CM); Basic configuration management Integration Reference Point (IRP): CORBA solution set.

[5] 3GPP TS 32.632 Telecommunication management; Configuration Management (CM); Core Network Resources Integration Reference Point (IRP): Network Resource Model (NRM).

ANNEX A: 3GPP IRP's

Interface IRP's

- Alarm IRP (32.111-x)
- Notification IRP (32.30x)
- Generic IRP (32.31x)
- Test Management IRP (32.32x)
- Notification Log IRP (32.33x)
- File Transfer IRP (32.34x)
- Performance Management IRP (32.41x)
- Basic CM IRP (32.60x)
- Bulk CM IRP (32.61x)
- Kernel CM IRP (32.66x)
- *Entry Point IRP (32.xxx)*

NRM IRP's

- Generic NRM IRP (32.62x)
- Core Network NRM IRP (32.63x)
- UTRAN NRM IRP (32.64x)
- GERAN NRM IRP (32.65x)
- Inventory NRM IRP (32.69x)
- *Subscription Management NRM IRP (32.xxx)*

Data Definition IRP's

- State Management IRP (32.67x)

Note: IRPs in italics above are in the early stages of development.

ANNEX B: SOLUTION SET EXTRACT

This Annex shows an extract from a solution set specification [4] showing the mapping from an Information Service Operation to a solution set method (In this case a CORBA IDL method) as shown in Figure B1

IS Operation (3GPP TS 32.602)	SS Method	Qualifier
getIRPVersion	get_basicCm_IRP_version	M
cancelOperation	BasicCmInformationIterator::destroy	O
createMo	BasicCmIrpOperations::create_managed_object	O
deleteMo	BasicCmIrpOperations::delete_managed_objects	O
setMoAttributes	BasicCmIrpOperations::modify_managed_objects	O

Figure B1: Solution Set Extract - Mapping Table

In figure B2 an extract from the Solution Set CORBA IDL code is shown

```
/**
 * Performs the creation of a MO instance in the MIB maintained
 * by the IRPAgent.
 *
 * @parm objectName: the distinguished name of the MO to create.
 * @parm referenceObject: the distinguished name of a reference MO.
 * @parm attributes: in input, initial attribute values for the MO to
 *   create; in output, actual attribute values of the created MO.
 * @parm attributeErrors: errors, related to attributes, that caused the
 *   creation of the MO to fail.
 *
 * @raises ManagedGenericIRPSystem::OperationNotSupported: The operation
 *   is not supported.
 * @raises ManagedGenericIRPSystem::ParameterNotSupported: An optional
 *   parameter is not supported.
 * @raises ManagedGenericIRPSystem::InvalidParameter: An invalid
 *   parameter value has been provided.
 * @raises UndefinedMOException: The MO does not exist.
 * @raises IllegalDNFormatException: The DN syntax string is malformed.
 * @raises DuplicateMO: A MO already exist with the same DN as the one
 *   to create.
 * @raises CreateNotAllowed: The creation of the MO is not allowed.
 * @raises ObjectClassMismatch: The object class of the MO to create does
 *   not match with the object class of the provided reference MO.
 * @raises NoSuchObjectClass: The class of the object to create is not
 *   recognized.
 */
void create_managed_object (
    in DN objectName,
    in DN referenceObject,
    inout MOAttributeSet attributes,
    out AttributeErrorSeq attributeErrors
)
raises (CreateManagedObject,
        ManagedGenericIRPSystem::OperationNotSupported,
        ManagedGenericIRPSystem::ParameterNotSupported,
        ManagedGenericIRPSystem::InvalidParameter,
        UndefinedMOException,
        IllegalDNFormatException,
        DuplicateMO,
        CreateNotAllowed,
        ObjectClassMismatch,
NoSuchObjectClass);
```

Figure B2: Solution Set Extract - CORBA IDL Code