International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.392

(04/2016)

SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Maintenance and operation – Disaster management

Disaster management for improving network resilience and recovery with movable and deployable information and communication technology (ICT) resource units

Recommendation ITU-T L.392

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node element (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	**L.380–L.399**
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T L.392

Disaster management for improving network resilience and recovery with movable and deployable information and communication technology (ICT) resource units

Summary

Recommendation ITU-T L.392 introduces an approach for improving network resilience against disasters and to assist network recovery after disasters by physically mobilizing units and facilities that package movable and instantaneously deployable resources for information and communication technology (ICT).

The movable and deployable ICT resource unit (MDRU) is a collection of ICT resources that are packaged as an identifiable physical unit, is movable by any of multiple transportation modalities, acts as a stand-in (substitute) for damaged network facilities, and reproduces and extends their functionalities. The MDRU also brings extra ICT resources to meet the great increase in communication demands expected in disaster areas.

Focusing on the use of the units as a substitute for local nodes, this Recommendation reviews target objectives of disaster management and gives high-level requirements for both operations and facilities as a guideline. To shorten deployment time, which is the primary objective of network recovery with substitute, this Recommendation shows how to optimize the process that starts with equipment preparation in daily operation to service offering at the site of the disaster.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.392	2016-04-13	15	11.1002/1000/12837

Keywords

Deployment process optimization, disaster management, disaster relief, MDRU, network resilience and recovery.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Table of Contents

Recommendation ITU-T L.392

Disaster management for improving network resilience and recovery with movable and deployable information and communication technology (ICT) resource units

1 Scope

This Recommendation describes an approach for improving network resilience and recovery by substituting healthy transportable and instantaneously deployable facilities for damaged ICT facilities; the substitutes are referred to as movable and deployable ICT resource units (MDRUs) throughout this Recommendation.

After introducing the substitution approach to network resilience and recovery, this Recommendation identifies key factors for examining various MDRU usage scenarios, and introduces one promising MDRU use as a local node. Focusing on this use, this Recommendation reviews target objectives of disaster management and gives high-level requirements for both operations and facilities as a guideline. To shorten deployment time, which is the primary objective of network recovery, this Recommendation shows how to optimize the substitution process, starting with equipment preparation for daily operation to service offering at the site of the disaster.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 movable and deployable ICT resource unit (MDRU): A collection of information and communication resources that are packaged as an identifiable physical unit, movable by any of multiple transportation modalities, and which act as a stand-in (substitute) for damaged network facilities, and reproduce and extend their functionalities.

NOTE – Packed into a container or box, an MDRU accommodates equipment for reproducing ICT services such as switches/routers, wired/wireless transmitters/receivers, servers, storage devices, power distribution unit, and air conditioners.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP third Generation Partnership Project

AAA Authentication, Authorization and Accounting

AP Access Point

BS Base Station

codec coder–decoder

DSP	Digital Signal Processor
EMC	ElectroMagnetic Compatibility
FWA	Fixed Wireless Access
HDD	Hard Disk Drive
HGW	Home GateWay
ICT	Information and Communication Technology
I/O	Input/Output
IP-PBX	Internet Protocol Private Branch exchange
LTE	Long-Term Evolution
MDRU	Movable and Deployable ICT Resource Unit
PC	Personal Computer
QoS	Quality of Service
SSD	Solid State Drive
TE	Terminal Equipment
UNI	User-to/-Network Interface
VM	Virtual Machine
VoIP	Voice over Internet Protocol
WAN	Wide Area Network
Wi-Fi	Wireless Fidelity

5 Conventions

None.

6 Introduction

Network resilience and recovery against disasters can be tackled by multiple approaches. The primary approach is to strengthen networks in operation as much as possible and to minimize potential damage. This approach includes redundancy, backups and switch-over of the system or part of it. The secondary approach is to prepare transportable replacements that can stand in for the operational networks. When a disaster occurs and part of the network is destroyed, the prepared resources are deployed immediately to the damaged area. The substituted units replicate the role of the lost network facilities. This approach works well when a severe disaster occurs and network facilities, protected by the primary approach, are destroyed or rendered impossible to fix quickly. These two approaches complement each other, as movable-and-instantaneously deployable ICT resources are expected to work together with the remaining ICT facilities, until local networks in the damaged area are recovered.

The movable and deployable ICT resource unit (MDRU) is expected to bring two benefits.

1) Quick recovery of the capabilities lost to enable the communications needed for disaster relief activities in the area.

2) Quick deployment of extra ICT resources that will increase network capacity locally and thus minimize the impact of the great increase in communication demand usually carried by facilities outside the devastated area. This traffic spike can cause wide area failures of the network.

As a consequence, movable-and-instantaneously deployable ICT resources enhance network resilience and recovery.

To promote the secondary approach, the MDRU should be identified and specified. It should be physically movable by the widest possible range of transportation modalities, deployed and made operational in the minimum time, capable of replicating the lost network facilities, and compatible with the remaining facilities. To make the MDRU meet these requirements, standard specifications are essential. The physical form of the MDRU to meet transportation requirements, implementation guidelines and operational instructions for minimizing the time needed to make the MDRU ready, underlying universal ICT resources and service-creating capabilities that are built-in, and the way of connecting to the core network and surviving terminals are all standardization matters. Realizing compatible and easy-to-operate resource units allows the units to be treated as shared resources that can be used efficiently against many different disasters. Even when provided by other operators, organizations, or foreign countries, units that follow the common specification can be made fully operational as if they belonged to the operator.

7 Usage scenarios of movable and deployable ICT resource units

Depending on disaster type and which parts of the network facilities survive the damage, there are many MDRU scenarios requiring different attributes, such as size and functionality. In this clause, the factors underlying MDRU usage scenarios are described first. Then, a promising MDRU application is introduced. Further information about transportable units is given in Appendix I.

[b-ITU-TR, 2013] includes a number of case studies of the performance of public telecommunications systems in recent disasters along with a review of activities related to the use of telecommunications for disaster mitigation.

7.1 Factors underlying movable and deployable ICT resource unit usage scenarios

The following factors should be taken into account when studying MDRU usage scenarios.

- Disaster types, severity and timing – Disasters can be characterized from the viewpoints of spatial extent and timing. First, the size and uniformity of the damage vary with disaster type. Some disasters, such as tsunamis, tend to create areas of large uniform damage. Other types, such as earthquakes, can yield relatively lightly damaged areas, in which facilities may survive, interspersed with heavily damaged areas. The type of disaster also changes the temporal pattern of damage. The timing viewpoint includes whether the disaster has sufficiently long lead times to allow prediction and thus preparation, and whether the end of the disaster can be reliably predicted, thus allowing the start of recovery procedures at full power. Hurricanes and typhoons can be predicted in advance, while earthquakes are hard to predict and secondary earthquakes are common.
- Expected damage and surviving network facilities – As a consequence of the disaster type and severity, specific network facilities are likely to be destroyed, while other facilities may remain operational with high probability. Each network facility and portion should be examined to discover whether they are prone to being damaged according to the type of disaster. Even in the case of a tsunami, for example, some facilities such as optical fibres may remain undamaged because of their water-shielding. An earthquake damages surface facilities rather than those underground. Resource units should be designed to replicate the greatest possible range of facilities, so as to cover as many eventualities as possible. The network facilities and portions to be considered are links to core networks, local data centres and telephone switches, access networks, residential facilities, and terminals.

  NOTE 1 – Availability of electric power supply or local backup battery lifetimes should be considered when estimating surviving facilities. If backup batteries are working, the real problems may occur not just after the disaster but also several hours after it when the batteries are exhausted.

NOTE 2 – Backups for public mobile networks (e.g., mobile switch centre, base stations and antennas) and their relationships with newly deployed MDRUs should be studied further.

- Conditions and possible behaviour of users – whether users are safe, which actions they can take and which actions they are trying to take, should be considered to estimate required communication services needed and the level of demand.
- Service types to be considered – It may be hard to provide all services at the same time or to recover all services at the same pace after a severe disaster, due to resource limitations. Priority may need to be introduced so that critical services are recovered immediately in given resource limitations.
- Types of ICT resources to be deployed – Local tangible physical objects, such as the integrated resource unit packaged as a container or a box, temporary antennas for satellite communications or remote access to cloud services are ICT candidates for deployment.

7.2 Usage scenario of an movable and deployable ICT resource unit as a local node

The MDRU, which simulates a local telephone switch and an edge node for Internet access, can be used to replicate a local network that has been destroyed. Figure 1 shows an example of an MDRU use case.

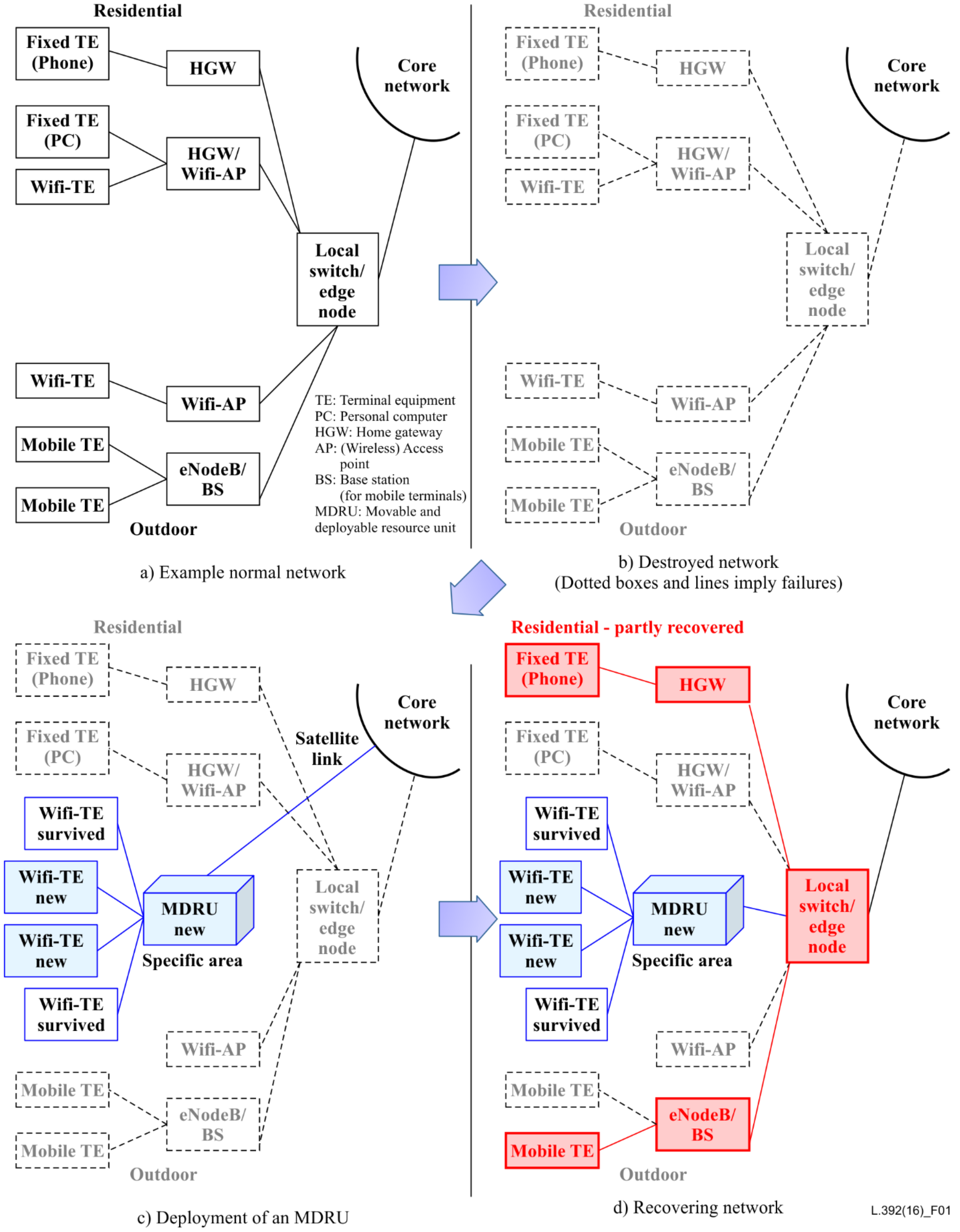

Figure 1 – Example of MDRU use for network recovery

If a tsunami attacks a fibered area, local data centres and telephone switch offices may be totally destroyed, while the fibres remain viable. Some residential facilities, such as broadband routers [shown as home gateways (HGWs) in Figure 1] and smartphones [shown as mobile terminal equipment (TE) in Figure 1], may also survive. Just after the disaster and several days thereafter, local voice communications and the distribution of local community information are the most crucial services to be provided. In such a case, the MDRU that replicates the local data centre servers and telephone switches is most effective for recovering local communications in the devastated area.

Figure 1 shows an MDRU use case and a recovery scenario for a destroyed local network. The scenario assumes that both residential and outdoor services are damaged due to a severe disaster as is shown in Figure 1 b). To provide urgent communication services over a particular area, an MDRU is deployed in the area and works as a local communication node [shown in Figure 1 c)]. The MDRU supports WiFi terminals both surviving and recent introductions. The MDRU shown provides a satellite link to access the core network. Long distance fibre is an alternative to access the core network. Users in the affected area download telephony applications from the MDRU and communicate with each other. It should be noted that access via satellite or a long distance fibre to the core network allows the MDRU to bypass the congested local switch, even if available or recovered, and thus offload traffic from the switch.

The destroyed network is recovered step-by-step as is shown in Figure 1 d). Once the public local node becomes available, the MDRU will switch from the satellite link to the broadband access to the node and thus support higher-speed services and more terminals.

It should be noted that Figure 1 shows the MDRU position from the overall network perspective. Terminals and access networks are modelled in an abstract way, and the actual access network technologies used, terminal capabilities and business relationships might alter the perspective. Viewed from the MDRU, whether and how to support specific equipment and relevant access networks needs further study.

8 Guidance to disaster management with the use of movable and deployable ICT units

According to the factors and assumed use case in clause 7, network operation and facility management in preparation for disaster should recognize the following conditions as uncertain.

Given conditions

− When a disaster occurs and how long it lasts.
− Where a disaster occurs and how large its impact could be.
− How severe is the damage caused by the disaster.
− How much additional or unusual demand the network should support.

In addition, with movable and deployable ICT resources, network heterogeneity should be taken into account.

Given the uncertainties above, the following objectives should be achieved for network recovery.

Objectives for network recovery

− Rapidity.
− Transparency, or nearly so, of recovery to users.
− Prioritization of critical communications, if not all communications can be recovered;
− Smooth transition from an irregular and disaster-specific to regular and normal service offering.

The following high-level requirements should be met to achieve the above objectives.

Requirements on network operation with substitute ICT resources

− Grasp of the current and damaged situation.
− Actions while acknowledging the uncertainties.
− Mixed operation of heterogeneous facilities, some of which are used for a regular and normal service offering, while some are for an irregular and disaster-specific service offering.

Requirements on substitute ICT resources

- Quick availability.
- Transportability.
- Robustness while being transported as well as operated.
- Multi-purpose design to meet unknown or changing demands.
- Support for some existing critical services in the face of extra and greatly increased demand.
- Support for disaster-specific services.
- Ability of operation by people who do not use facilities regularly.
- High connectivity with surviving facilities, while not harming them at all.
- Cost effectiveness with adoption of latest technologies.

9 Consideration on shortening the deployment process

9.1 Outline of deployment process

The main objective of network recovery is to rapidly resume the ICT services that are suspended in a damaged area. With the use of the substitute ICT resources, the issue comes down to how quickly they can be prepared for work. To shorten the delay, the entire process associated with deployment of substitute ICT resources should be reviewed and reduced by optimization. This clause describes an enhanced deployment process suitable for MDRUs.

Figure 2 shows an outline of the deployment process for MDRUs. The process starts with daily and regular preparation in the ordinary phase. After a disaster occurs, the process moves to preparation for restoration, which is specific to the disaster. This is followed by transportation of units and the installation of each unit at the disaster site. On site, service set-up starts when the installation of the ICT unit is completed and the unit becomes ready to use. Services recommence upon completion of service set-up. The process then shifts to service operation.

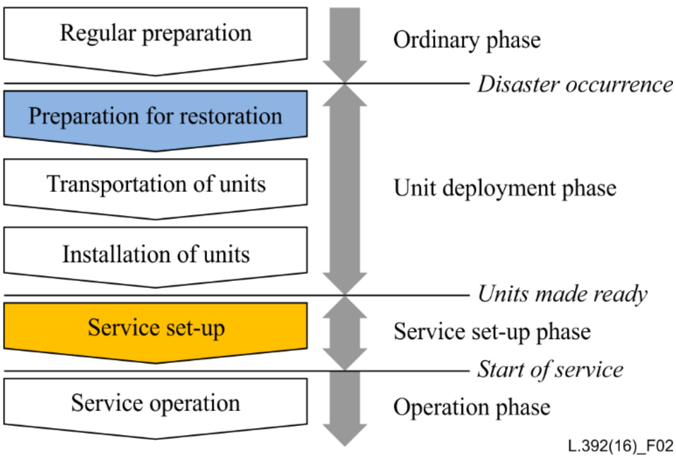

Figure 2 – Outline of process with movable and deployable ICT resource units

The duration of deployment, which extends from disaster occurrence to service operation, is determined by two main factors: unit delivery and service set-up, which are discussed in the following optimization stage.

9.2 Process optimization

Figure 3 shows optimization of the time taken to deploy MDRUs.

Tasks in preparation for restoration and service set-up

Work in preparation for restoration, which is specific to and initiated just after the disaster, can be divided into three tasks: (1) system/network design; (2) procurement of physical resources; and (3) data preparation. The time taken is reduced by shifting some tasks to regular preparation. In other words, the ICT infrastructure needs to be prepared as much as possible before the disaster.

Work for service set-up can be divided into four tasks: (4) interconnecting ICT units; users' devices and WAN; (5) system activation; (6) data installation; and (7) test.

Three approaches for optimization

In the optimization, three approaches are taken to:

a) shift some tasks in the deployment and service set-up phases to the ordinary phase;

b) automate some tasks; and

c) perform some tasks concurrently.

Optimization

In approach a), the tasks shown in the middle of Figure 3 are rearranged so as to reduce the time needed for the deployment and service set-up phases. Tasks (1) to (4) and (6) are moved to the ordinary phase as much as possible. Specifically, typical deployment process patterns, which are flexible enough to support various disaster situations, are prepared beforehand and formalized as guidelines. When a disaster occurs, operators select one of the patterns to be applied to the case and follow the guideline.

In approach b), several tasks in the service set-up phase are simplified or automated. To support user devices and to connect access networks around the unit, the unit can, for example, use WiFi instead of wired connections like optical fibres. The use of wireless technology for access network connection dramatically reduces the time needed to connect the user devices to the unit. In some advanced scenarios, WiFi access points are automatically configured to form a mesh network around the unit by broadcasting control signals from the unit to access points near the unit. To control the unit itself, the start-up process can be embedded in the unit's control software. Once an operator activates the unit remotely, the whole system automatically starts up according to the programmed sequence and becomes ready to use.

In approach c), parallel processing is applied. Some independent tasks like physical wireless network configuration and service set-up are concurrently performed. Assume that user devices are registered with the unit [working as an internet protocol private branch exchange (IP-PBX)] when they first attempt to access the service. The registration performs both data installation and tests for the interconnection of the user device to the unit. The customer database is therefore generated concurrently with service operation, so initial data installation is minimized and simplified.

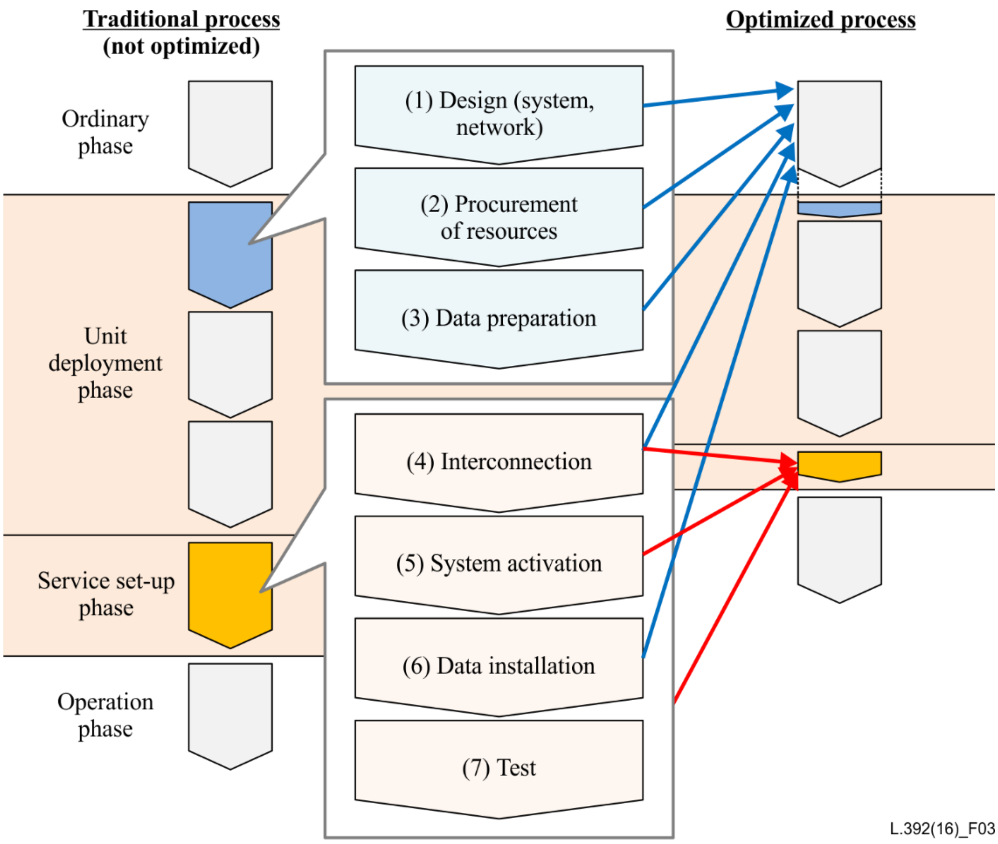

Figure 3 – Optimization of process for movable and deployable ICT resource units

10 Security consideration

To combat the consequences of severe natural disasters and provide the rapid network and service recovery needed, security criteria that are different from those in normal operation may be applied. Careful consideration is necessary.

In this Recommendation, the following descriptions are relevant to security considerations.

– The MDRU is assumed to be connected to the public network via the user-to-network interface (UNI), which provides secure connection from the public network perspective.

– It is recommended that the MDRU support flexible authentication, authorization and accounting (AAA) management, some of which allows light AAA management and rapid service offering.

Appendix I

Information about movable and deployable ICT resource units

(This appendix does not form an integral part of this Recommendation.)

This appendix gives help in understanding the profile of MDRUs by an example of realization and possible requirements or requirement categories.

I.1 Design principles for movable and deployable ICT resource units

The following principles are to be recognized when MDRUs are designed and related standards are discussed.

Disasters create a network situation where the resources are unknown, heterogeneous, and quite limited. To cope with such situations, MDRUs should be designed to:

- provide bare minimum connectivity via the essential parts of the standards;
- achieve fluidity and mobility of node functionality to substitute for function-rich network nodes, which need a very long time to recover;
- offer easy, rapid and automated configuration to shorten the time to service delivery;
- be adaptable and dynamic for control and operation to maximize the use of limited available resources;
- support security and privacy to restore the original complex ICT environment as much as possible.

I.2 General requirements for movable and deployable ICT resource units

This Recommendation focuses on container-type MDRUs that simulate data centre servers and local office switches. This clause describes the top-level requirements to be met to allow common and wide use of the MDRU. Figure I.1 shows general MDRU requirements, which are described in clauses I.2.2 to I.2.6.

NOTE – Other MDRU types, such as van-type vehicles, need further study. [b-Sakano, 2015]

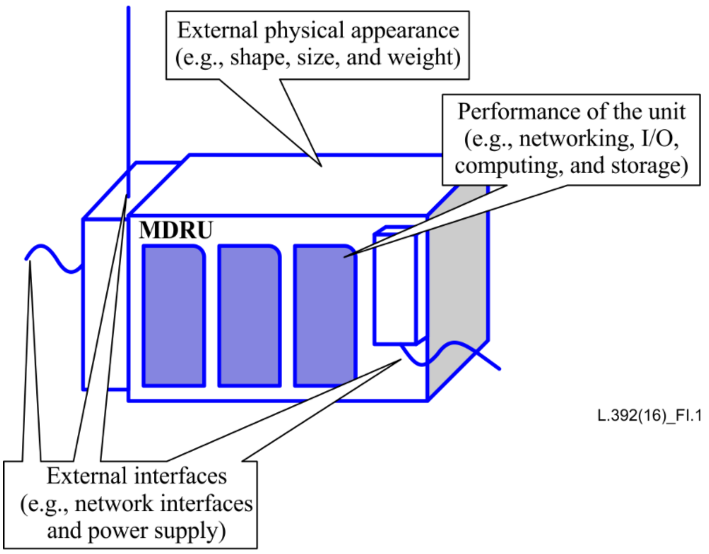

Figure I.1 – General movable and deployable ICT resource unit requirements

I.2.1 Example of implementation

Figure I.2 to Figure I.6 illustrate an example of MDRU implementation. Figure I.7 shows another MDRU implementation, i.e., installation in a van-type vehicle.

Figure I.2 – Transporting a movable and deployable ICT resource unit to a remote site

Figure I.3 – Deploying and configuring a movable and deployable ICT resource unit at a remote site

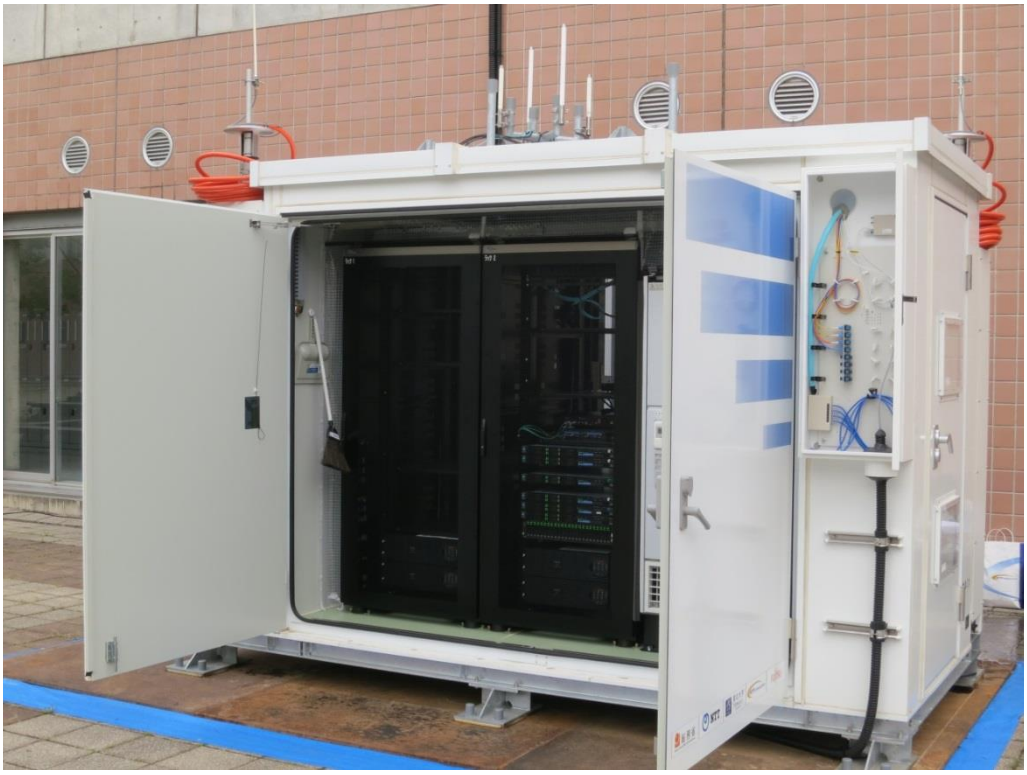

Figure I.4 – Opening the front panel of a movable and deployable ICT resource unit

Figure I.5 – System configuration and start-up of a movable and deployable ICT resource unit

Figure I.6 – Components inside a movable and deployable ICT resource unit

Figure I.7 – A van-type movable and deployable ICT resource unit

As shown in Figure I.8, the MDRU is normally installed near the disaster response centre or a shelter to enable construction of a wireless access network. In addition, fixed wireless access (FWA) systems can be set up to allow communication with remote shelters.

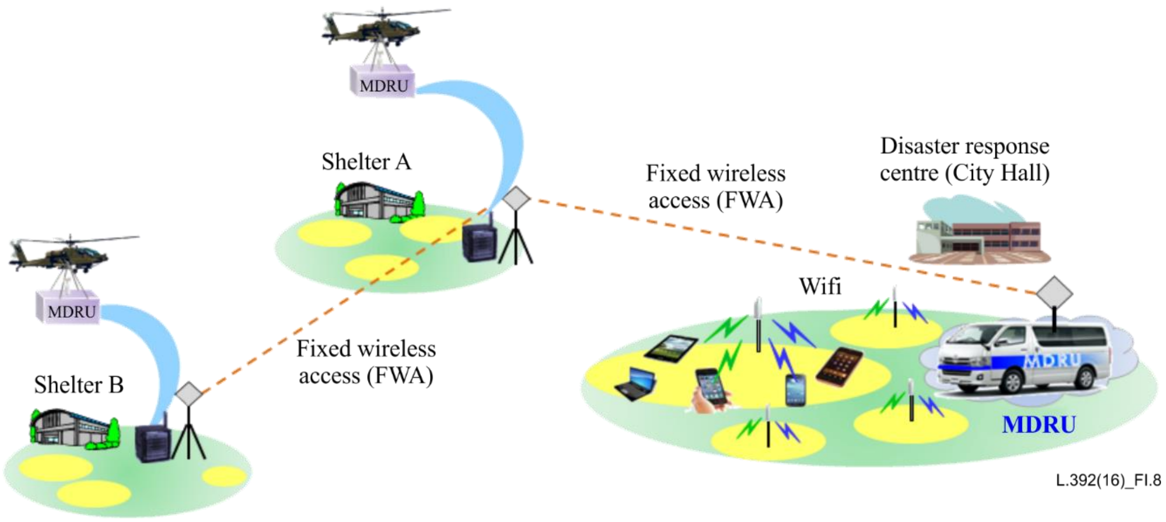

Figure I.8 – Communication between shelters via a movable and deployable ICT resource unit

In certain conditions, it may be difficult to bring even a small vehicle-type MDRU into the disaster zone. In such a case, a briefcase-type MDRU, which is made easier to transport by limiting its capabilities, can be brought in to provide a limited range of information and communication services. Figure I.9 shows a case where a briefcase-type MDRU provides only a telephone service.

By selecting an appropriate type of MDRU, it is possible to provide as many information and communication services as possible in a disaster-stricken area, depending on the conditions in the area.

Figure I.9 – Briefcase-type movable and deployable ICT resource unit

I.2.2 External physical appearance

The most fundamental requirement of an MDRU is its ability to be conveyed by ordinary transportation. To meet this requirement, the basic physical appearance should be specified.

The MDRU is required to comply with physical appearance standards as follows.

Basic physical parameters:

− shape, size, and weight;

NOTE 1 – Long antennas hinder transportation. They should be dismantled and assembled when installed. The extendible antenna is another solution to easy transportation.

when carried:

− tolerance against transportation stress (e.g., degree of tilt and shock loads);
− capabilities that remain operational even when carried;

NOTE 2 – To reduce system set-up time, some capabilities should remain in the hot state even while the unit is being transported.

After installation:

− electric power to be supplied or battery capacity if it is equipped with the unit;
− electromagnetic compatibility (EMC) requirements to be met;
− tolerance with respect to temperature and humidity; and
− conditions in operation such as indoor or outdoor.

I.2.3 External interfaces

To connect with network facilities toward the core network and to accommodate surviving access networks and terminals, interfaces to support the two should be specified.

The MDRU is required to support specified external interfaces to connect with network facilities towards the core network and to accommodate surviving access networks and terminals. The specification should cover physical to logical interfaces on each layer.

NOTE – As for physical implementation, radio and fixed cable interfaces should be considered.

I.2.4 External logical appearances

It is crucial to mobilize sufficient ICT resources (provided by MDRUs) and sufficient service capabilities over the resources to satisfy the requirements of a devastated area. To treat multiple MDRUs in the same manner without concern for machine-specific or manufacturer-specific settings, parameters associated with the MDRU should be the same.

The MDRU is required to express its logical appearance, which should characterize the fundamental capabilities of the MDRU, its quantitative capacity and related performance. Standard specifications should provide a set (or a limited number of sets) of reference parameters and target values.

The MDRU reference parameters should, at least, characterize the following fundamental capabilities:

− supported input and output (I/O) interfaces (in terms of physical medium type, their speed, and the number of ports);
− networking (with regard to address space capacity for dynamic allocation, registration, routing and switching throughput, and the number of end terminals supported);
− computing capacity (usually indicated in the number of the reference processers);
− storage [the size of available memory on board and on hard disk drive (HDD) or solid state drive (SSD)].

I.2.5 Preferred setting of a movable and deployable ICT resource unit

To encourage the introduction of MDRUs into particular disaster scenarios or damaged areas, some typical settings of the capabilities and performances of the MDRU may be specified as useful references.

The following are initial considerations for those reference settings.

− Standalone or building block type.

  NOTE – A building block-type MDRU assumes its use in combination with other units that interact with each other and provide higher performance in total.

− Super light type.

− Switching-intensive, interface-rich, processor-intensive, or memory-rich type.

− Ultra power saving type.

− High- or low-temperature tolerant type.

− Types intended for rural or urban areas.

I.2.6 Consideration of movable and deployable ICT resource unit size

As discussed in clause I.2.1, there is a variety of MDRU implementations ranging from a train-transporting container to a compact easy-to-carry briefcase. Although components inside MDRUs are supposed to be modules, which should allow any of them to be used in combination and meet any package size, larger-size implementations have some scale merit. They can provide larger capacity and full functionality by themselves. Smaller-size implementations can answer high mobility, which is hard to achieve with large and heavy boxes.

This clause gives consideration of how an MDRU is designed, selected and prepared.

− Transportability: Weight and size are the dominant factors for being transportable. Speed to transport and time to recovery determine the effectiveness of MDRUs. Standards of transportation means (train containers, helicopters and military transport, and ordinary cars) should be considered when choosing size and weight.

− Geographic area to cover and time to deployment: Depending on the area to be covered and duration to use, MDRU size varies. In some case, MDRUs will be (semi-) permanently used. For such a long-term use, larger (i.e., capacity-rich and function-rich) and more tolerant implementations, which are hard to achieve by the combination of handy implementations, are preferable.

− Reachability from the core network: As is seen in the cloud, many services can be provided from a remote cloud if a broadband path is available to the MDRU. Otherwise, local site resources and capabilities brought by MDRUs need to be rich and larger size is preferable.

Figure I.10 shows a possible menu of MDRU implementations in terms of resource capacity and mobility.

New criteria and parameters for designing appropriate MDRUs are discussed in clause I.3.2.8.

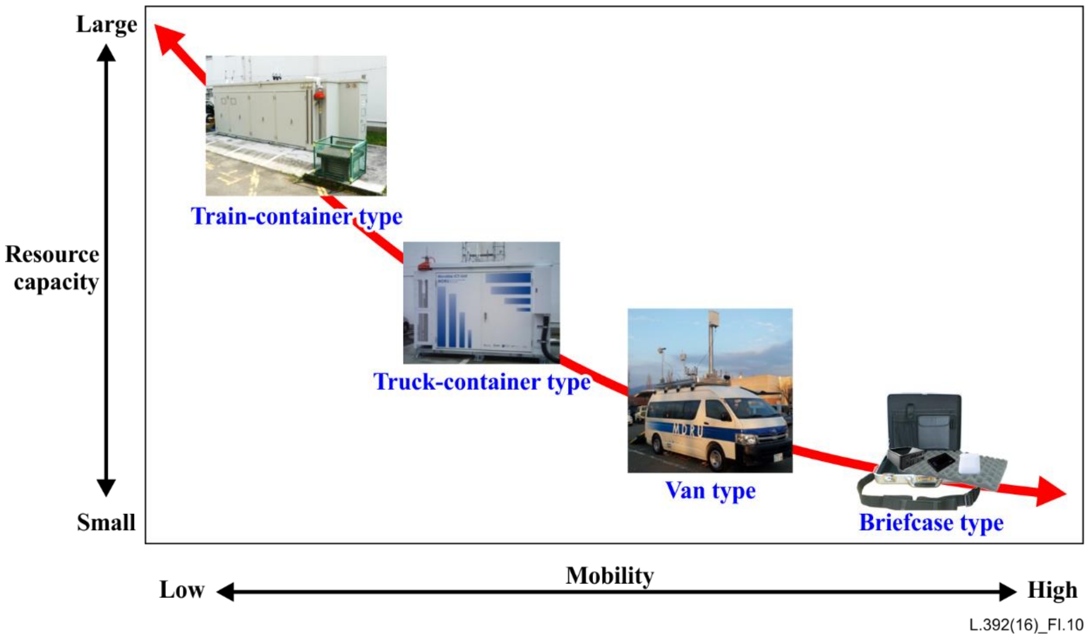

Figure I.10 – A menu of movable and deployable ICT resource units

I.3 Service-provisioning and network operation requirements

Following the top-level requirements above, the next level requirements refer to the service-specific aspects and the network operation aspects.

I.3.1 Service-specific requirements provided for users

Depending on the type of disaster and requirements in the devastated area, particular services are targets for recovery.

I.3.1.1 Telephony and related services

The real-time communication service, which includes voice and video telephony, reflects the existence and activity of the communicator. The service is considered essential for reassuring people that their family and friends are safe and sound. The service is also useful for supporting the assured and stable work environment necessary for rescue operations.

The MDRU is required to support the real-time communication service. The following are included in the service:

− ordinary voice calls;

− complementary services such as multi-party calls, text messaging, presence, and voice mail;

− access to and download of the application that provides the services above.

In support of the above services, the MDRU is required to support the followings capabilities:

− identification of terminals or users (i.e., numbering, naming and addressing);

NOTE 1 – In some case where the MDRU is to be operated without any interaction with public networks, the original numbers associated with the subscribing operator may not be available. Alternative identification, authentication and authorization schemes should be considered.

− registration of terminals or users;

NOTE 2 – If simpler operation is required, AAA for terminals or users may not be necessary. Logging of use may compensate for AAA.

− connection/session set-up, release, and management;

NOTE 3 – The connection and session includes calls between one terminal in the damaged area and one in an undamaged area. Traversing networks and gateways involved in the calls should be considered. The networks include the network established by the MDRU and other public undamaged networks beyond its control. To locate and operate the gateways properly is another issue for network planning. The consideration should cover both incoming and outgoing calls to and from the damaged area.

NOTE 4 – In the case of a large-scale disaster, multiple MDRUs may be installed, each of them supporting a particular area independently. Some of the MDRUs may become interconnected or disconnected. Some of them may be connected to the core network or disconnected. Depending on the disaster and resultant damage, the interconnections may be intermittent. Scenarios and required capabilities need further study;

- congestion avoidance and prioritized call handling;
- adequate security and privacy.

One example of implementation is the operation of the MDRU as an IP-PBX, which tentatively accommodates smartphone users via the voice over internet protocol (VoIP) application. Terminals outside the disaster area identify the IP-PBX as a dedicated number and the terminals under MDRU control are identified with the dedicated number as a prefix. The terminals directly accommodated by the IP-PBX are reachable by local (original) numbers, while they are reached by two-step dialling from outside the disaster area [b-Kotabe, 2015].

I.3.1.2 Data centre services

If network facilities associated with Internet access are destroyed, all Internet services will be stopped in a certain area. To cope with this situation, the MDRU is expected to offer alternative Internet access by providing temporary communication channels (e.g., via satellite). If the temporary channel is limited or impossible, it is also expected that the MDRU works as an independent local data centre and provides Internet-type services by itself to local users. The following are tentative requirements in support of this scenario.

The MDRU is required to provide alternative routes for Internet access to handle cases where original Internet access has been dropped.

The MDRU is required to provide a virtual machine (VM) and web applications running on the VM.

The MDRU is required to support web-based information services and related database management by itself, even if Internet access is not available.

It is recommended that the MDRU support migration of local web–based services and related database management to the Internet service when Internet access becomes available.

I.3.1.3 Services for early warning and disaster relief

[b-FG-DR, 2014] describes: 1) alarm services for imminent disasters as early warnings; and 2) services to support people in the devastated area as disaster relief. Further investigation is necessary to support these identified services by the MDRU.

Other services and applications for disaster relief are described in [b-ITU-T E.108].

Example services to be studied are as follows.

- Information distribution from authority to ordinary citizens in the damaged area (one-to-many multicasting or broadcasting).
- Directory of afflicted people in the damaged area: instead of collecting papers and using message boards, database creation about people in the area is the very first task to be done. The task includes user ID allocation, profile registration and maintenance.
- Local information sharing inside the damaged area (information upload and retrieval or event notification service with or without subscription).
- Information publication from the damaged area to undamaged areas.
- Other information services.

I.3.2 Network operation requirements

The following are the requirements of MDRU operators.

I.3.2.1 Agile deployment and installation through all processes and operations

The MDRU is required to be deployed and installed in an agile manner. The requirement should cover all processes of operations.

− Time reduction in the planning phase: Planning the use of MDRUs and their preparation including procurement should be shortened. Reference manuals for MDRU preparation may be useful.

− Time reduction for the system configuration phase: Schemes and technologies should be investigated that divide the conventional interrelated configuration processes into independent ones and thus allow parallel processing to reduce configuration time. This may involve simple process examination and re-arrangement. It also includes separating the interrelated processes, which are to be treated in a sequential manner, into independent ones by resource abstraction technologies.

− System configuration in the transport phase: It is recommended that MDRUs be configured before the system is deployed and installed in the target area, even while it is being transported. The configuration process should be re-organized so as to minimize the processes needed after installation at the damaged area. To improve system stability for in-transport processing, more robust devices, such as solid state drives (SSDs), should be considered, rather than hard disk drives (HDDs).

− Mobility and fluidity of applications: To shorten the application installation time and continue the service with minimum interruption, cloud-computing live migration of the MDRU resources should be investigated. It should be noted that this is valid only when the MDRU is connected to the core network and the cloud service is available through the core network.

I.3.2.2 Local switch and access server replication

The MDRU is required to replicate the functionalities of main node functions, such as telephony switches, access servers to the Internet, and ICT servers.

The MDRU is required to provide intensive ICT resources; these will be needed to meet the greatly increased demands raised by post-disaster communications.

The MDRU is required to operate as a user facility from the public commercial network viewpoint and to be connected to the public commercial networks via their UNI interface. This provides the MDRU with stronger connectivity without regard to operator-specific restrictions and thus enables quick replication. The UNI connection is also favourable for the public networks to secure the network.

The MDRU is required to work in a standalone fashion, and so should not mandate any connection to the public network while providing local services by itself.

The MDRU is also required to work with the functionalities in the core networks, when they are available, in a cohesive manner.

I.3.2.3 Access network recovery

Recovery of access networks in the damaged area is one of the critical tasks.

The MDRU should make maximum use of surviving access network facilities, as available, to recover user and terminal reachability.

Remaining access and user network facilities may be used more efficiently with a slight configuration change. One example is to reconfigure surviving residential WiFi access points so as to connect with each other and build a transient local network as a new operation mode. Several technical issues have been identified, namely: the nature of the trigger to change the operation mode of WiFi access points, how the trigger should be given, how the local network should be created and how packets should be forwarded through the resulting network [b-Shimizu, 2015].

I.3.2.4 Mobile terminal support

Thanks to advanced terminal capabilities and strong demands for their use for public safety, including disaster recovery operations, direct communications and group communications among some long-term evolution (LTE) terminals are under consideration in the third generation partnership project (3GPP) release 12 and onward.

The MDRU may work well with those terminals by providing local database and information processing to offset the lack of core network connectivity. Support of those advanced mobile terminals by the MDRU is for further study.

I.3.2.5 High-speed transport (up to 100 Gbit/s) over unknown fibres

In some disasters, fibre remains available even though termination devices are damaged. An intelligent fibre-termination device that accommodates unknown fibres, adjusts its characteristics to the fibres automatically and provides the maximum throughput is another technical challenge. Recent digital signal processors (DSPs) applied to optical signal processing allow fine tuning and make the adjustment possible.

I.3.2.6 Media processing enhancement

To make maximum use of limited resources (such as storage and bandwidth), contents of communication sessions may be further compressed while maintaining the minimum level of meaning. Enhanced media processing, i.e., changing the codec of the same media type or changing the media type itself while maintaining the meaning of the contents can be useful.

After a disaster, normal user procedures that rely on the traditional method may be damaged or not work properly. For example, users may lose their mobile phones and thus their stored number directories; few people have memorized the numbers of their relatives. For elderly people who still rely on fixed phones, they are not reachable if the phone is lost. Voice and face recognition to eliminate the need for relying on telephone numbers may be helpful for identifying users and their messages.

Just after a disaster, network configurations become too complicated to operate in the normal way. To save time and resources, some service may be offered without precise accounting of their use. Only overall records of use may be stored for later detailed analysis. Enhanced log analysis may be necessary.

Complicated and unstable network configurations may create problems that are hard to diagnose in the normal way. It would be useful to identify what type of network information is the best indicator of abnormality. Collection and analysis of the large volume of data is another challenge in the media processing domain.

The following are candidate areas for media processing enhancement for the MDRU:

- media codec or type change to suit the limited resources available and to economize on their use (such as storage and transmission bandwidth);
- voice and video recognition for user identification and communication support;
- usage log analysis;
- fault notification collection and their analysis for fault management.

I.3.2.7 New network quality of service and performance criteria allowing for heterogeneous network operation

The situations necessitating MDRU deployment are quite different from those of normal network operations. Quality of service (QoS) and performance requirements of the so-called heterogeneous network consisting of public networks and MDRUs may be different from the normal homogeneous situation. By introducing a new set of criteria for them, the operator can run the heterogeneous network in a flexible manner.

Some QoS and performance objectives (e.g., for voice calls) need to be maintained for the heterogeneous network; some may be stricter (e.g., emergency services), while others can be degraded (e.g., video entertainment).

I.3.2.8 New criteria and parameters for designing appropriate MDRUs

There can be different types of MDRUs, e.g., in terms of size. A criterion for showing the effectiveness of each type may be useful. A guideline based on the new criteria would be helpful in estimating the appropriate number of units and their capacities against the expected damage caused by disasters. Consideration of MDRU size is given in clause I.2.6.

I.4 Other open issues

This clause briefly lists the issues related to MDRUs.

− Cost consideration – even against severe disasters, we are unable to make unlimited investments for backup facilities such as MDRUs. Reasonable cost calculation methods to justify the investment are necessary.
− Life cycle consideration – Similar to other network products, the MDRU should use the latest technologies. Different from others, the MDRU may have a longer time span, which may need longer term product maintenance. Maintenance for long-life-cycle products should be considered ranging from individual devices for repair to maintenance engineer skills.

Appendix II

Disaster management with MDRU: Feasibility study in the Philippines

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

The islands of the Philippines lie in the typhoon corridor of the Pacific region and experience an average of 20 typhoons per year. Typhoon-fed storms and high water are the most critical problems for the Philippine government and its residents. In November 2013, the Visayas region of the Philippines felt the full force of super typhoon Haiyan. Typhoon-fed storm surges grew to several metres high along the sea coast and caused widespread devastation in the area, similar to that of a tsunami. To make matters worse, the communication blackout obstructed attempts to evacuate people. 6 300 people lost their lives in the typhoon, and the numbers of missing and injured people are 1 061 and 28 689 [b-NDRRMC].

National disasters are on the rise, and thus, the United Nations and the international community are continuing efforts to find ways to reduce the risk of natural disasters, prevent the loss of lives, and reduce economic losses. In the process, the Government of Japan and ITU are collaborating to provide assistance to restore telecommunication connectivity in one of the islands most affected by typhoon Haiyan. On 13 May 2014, the Ministry of Internal Affairs and Communications (MIC) in Japan, the Department of Science and Technology (DOST) in the Philippines and ITU finalized a co-operation agreement for a feasibility study on restoring connectivity through the use of the MDRU and launched the project.

II.2 Summary of the ITU project

The ITU project, entitled Feasibility study of restoring connectivity through the use of the movable and deployable ICT resource unit, was inaugurated in May 2014 with the objectives of studying the effectiveness of the MDRU in providing immediate communications infrastructure and IT (information technology) facilities in the worst disaster-stricken areas in Cebu, Philippines, and in studying the viability of the MDRU as a communication solution in the aftermath of a disaster. San Remigio municipality on Cebu Island was the location of the MDRU feasibility study. The municipality consists of 27 barangays, or districts, and has a population of about 64 000. Onsite reports of the disaster were gathered manually because all communication networks had been destroyed (Figure II.1). The only source of communication to the government was through a satellite phone from the office of the mayor.

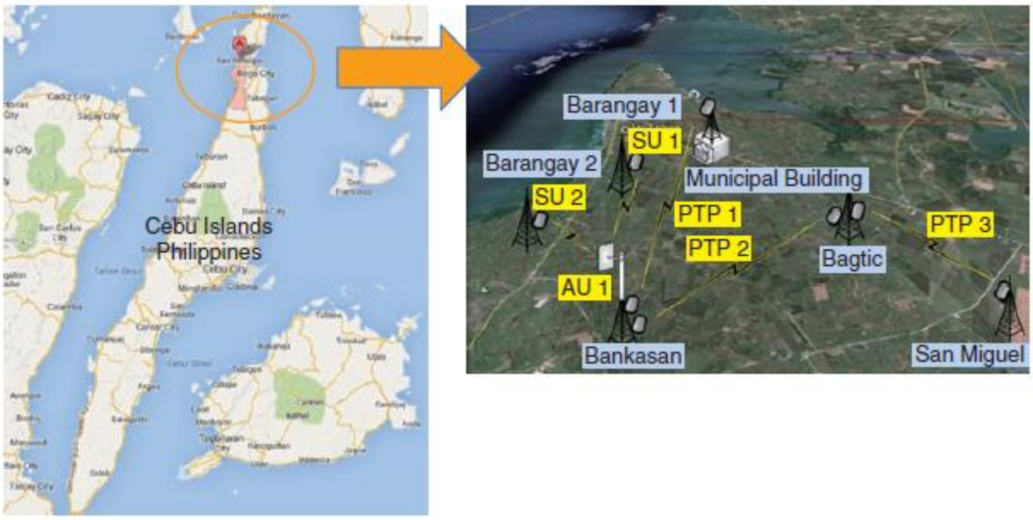

Figure II.1 – Location of San Remigio municipality in the Philippines and depiction of wireless network in San Remigio before the typhoon. (The network was destroyed by the typhoon.)

A summary of the feasibility study is given in Table II.1. The scope of this feasibility study covers technical testing as well as sustainable operation and management, including the provision of training to local staff and improving the disaster management planning structure in local communities for increased disaster preparedness.

Table II.1 – Summary of project

Project scope	Test the feasibility of the newly developed MDRU in disaster-affected areas, including a suitable location for installation. Provide adequate training to local key personnel for sustainable operation and management of the MDRU network. Improve disaster management planning structure in local communities for increased disaster preparedness. Gain feedback from government organizations and local communities on the services powered by the MDRU. Provide feedback on the project to government organizations through monitoring and evaluation of the installed MDRU.
Project management	The project is led by ITU. The ITU Project Manager provides the overall administration of the project in close collaboration with MIC and DOST. A steering committee was established immediately after the signing of the co-operation agreement.
Monitoring	ITU will monitor and evaluate the project based on the expected results and key performance indicators.
Term	May 2014 – September 2015

II.3 Launching the feasibility study

After agreement of the co-operation contract among relevant companies, preparation for the feasibility study was started in collaboration with local government staff members and residents. The installation of the MDRU, project administration and support were jointly carried out by Japanese and Filipno private companies. Japanese companies provided the MDRU server unit, the MDRU wireless system and heavy-duty smartphones. The MDRU server unit and the MDRU wireless system used in the project are shown in Figure II.2. They were installed in December 2014 in the San Remigio Municipal Hall and the wireless equipment was installed in a national high school (about 400 m away from the hall) where an evacuation centre had been set up. Point-to-point wireless equipment provided a communication link between the Municipal Hall and the high school. The MDRU team established a wide area WiFi network by employing an access point to access point (AP–AP) connection between the WiFi APs at the municipal hall and those at the high school, and a 24 GHz FWA connection between the two buildings [b-Shimizu, 2015]. We confirmed through the feasibility study that the MDRU operated effectively in the environment in the Philippines even though there were some differences between Japan and the Philippines.

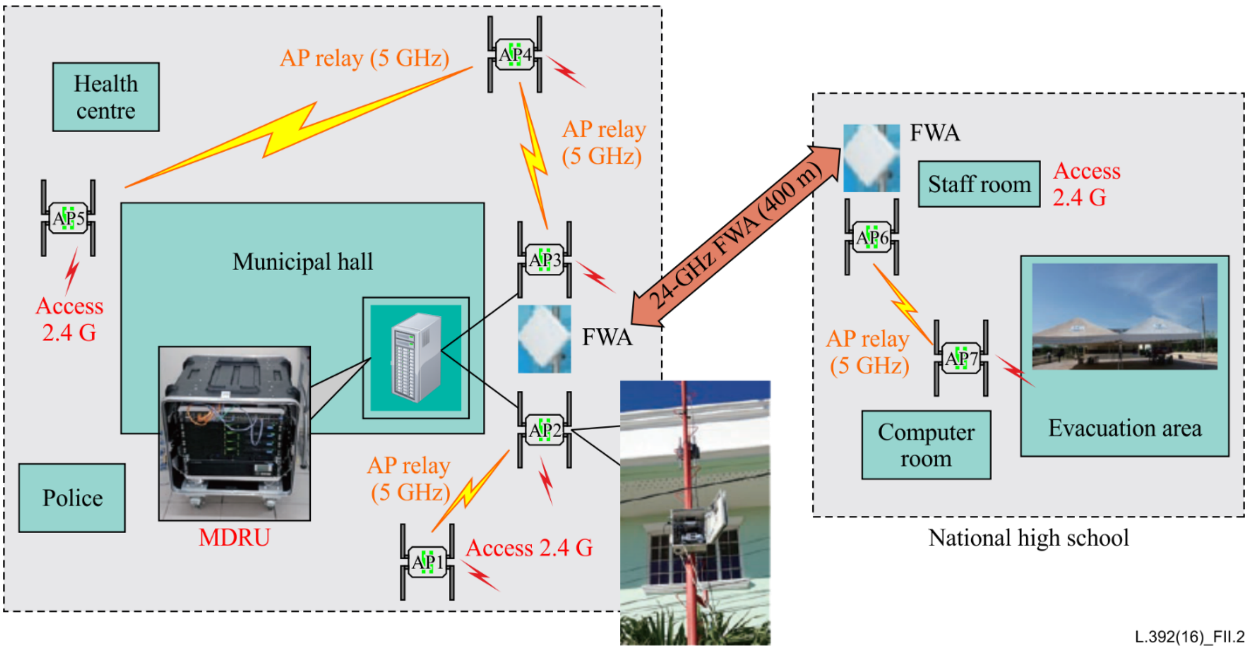

Figure II.2 – Movable and deployable ICT resource unit and wireless equipment installed in the San Remigio Municipal Hall and in a high school

An example of use in the event of a disaster is shown in Figure II.3. In this case, the mayor first called municipal employees on the phone to get information about the disaster. Then, the municipal employees took pictures of the disaster-affected area with a smartphone and saved them on the server in the MDRU. This enabled the mayor to gain a visual understanding of the disaster-affected area by looking at the pictures stored on the server. The mayor then instructed Municipal Hall employees to provide relief goods to the affected area and then reported on the situation to the central government.

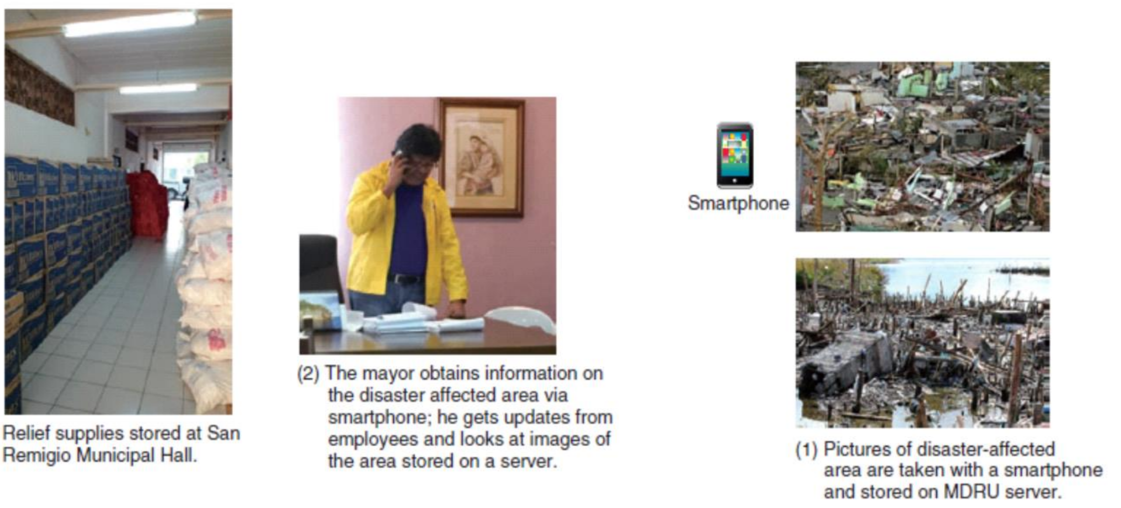

Figure II.3 – Use case of a movable and deployable ICT resource unit: Investigating the extent of damage from the typhoon

It is planned to continue working to improve some operation rules, the connectivity and the specifications of the MDRU by conducting a feasibility study of each use case in order to meet the needs of municipal employees and local residents.

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Printed in Switzerland
Geneva, 2016