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

Requirements and framework for low-cost sustainable telecommunications infrastructure for rural communications in developing countries

Recommendation ITU-T L.1700

International Telecommunication Union

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

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Recommendation ITU-T L.1700

Requirements and framework for low-cost sustainable telecommunications infrastructure for rural communications in developing countries

Summary

The objective of Recommendation ITU-T L.1700 is to identify general requirements and framework for low-cost sustainable telecommunications infrastructure with a special focus on rural communications in developing countries. The purpose of this Recommendation is to quickly and inclusively bridge the digital divide.

As a framework Recommendation, it is largely technology-neutral with focus on general requirements and metrics. It is intended that a series of Supplements be produced to provide technology-specific examples of best practice.

To bridge the digital divide, it is recognized that there will be potential users in remote or rural areas who are unlikely to gain digital services based solely upon conventional urban practices and needing a positive return on investment (RoI). Some indication is given on how additional funding or human resources may be obtained to bridge the financial gap and so enable the benefits of online services to be brought to individuals and communities.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Backhaul networks, digital divide, rural communities, telecommunications infrastructure.

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FOREWORD

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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.

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Introduction

Goal 2 of the ITU Connect 2020 Agenda for global telecommunication/information and communication technology (ICT) development addresses inclusiveness with an overall target to "Bridge the digital divide and provide broadband for all". The intention of this Recommendation is to address this problem focussing on telecommunications infrastructure and to show examples of new broadband technologies and best practices. One example of a definition of "Broadband" was given in early 2015 by the United Sates Federal Communications Commission (USFCC) as 3 Mbps (up)/25 Mbps (down).

Developing countries are seeking economic development using ICTs. Even rural areas can undertake outsourced businesses or offer back-office services, with just high-speed internet and a device with internet capability. E-education, e-health and other e-services are also anticipated and will improve the quality of lives and economic productivity in local communities.

Thus, urban-to-rural backhaul telecommunication infrastructure needs to be implemented nationwide as soon as possible. The priority should be its ultimate affordability, followed by the best reliability since ultimate affordability may not coexist with the highest reliability.

Affordability (capital expenditure (CAPEX) and operating expense (OPEX) including long-term total cost of ownership) would be improved if installation, operation, maintenance and repair of the infrastructure were supported by the local community in a do-it-yourself manner. The digital divide would not be closed if the investment goes only where the expected short-term return on investment is greater than 1.

The main objective of this Recommendation is therefore to identify the technology-independent requirements for ultimately affordable telecommunication infrastructure combined with best-effort reliability. It is strongly desired for developing countries to start implementing urban-to-rural broadband backhauls ahead of the rapidly evolving Internet of things (IoT) era in order not to further increase the digital divide. It is hoped that the ultimately affordable solutions meeting the requirements of this Recommendation can be quickly and widely implemented. To do this, grant assistance, loans of official development assistance (ODA) and even private funds may be required.

Recommendation ITU-T L.1700

Requirements and framework for low-cost sustainable telecommunications infrastructure for rural communications in developing countries

1 Scope

This Recommendation identifies technology-independent general requirements for ultimately affordable urban-to-rural broadband backhaul infrastructure, for connecting rural, remote and sparsely populated areas in developing countries.

Affordability here considers both CAPEX and OPEX of the solution to arrive at the long-term total cost of ownership. The reliability of the solution should be enhanced as far as possible to cope with harsh natural environments and difficult societal conditions specific to remote or rural areas in developing countries, although ultimate affordability may not coexist with highest reliability.

Flexibility and scalability are also needed so that the network can, over time and demand, expand telecommunications coverage both in number of users and bandwidth. In addition, environmental friendliness is becoming increasingly important.

Details of the technological solutions are to be provided in Supplements. User terminals are out of the scope of this Recommendation.

2 References

None.

3 Definitions

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ARPU Average Revenue Generated per User

CAPEX Capital Expenditure

ICT Information and Communication Technology

IoT Internet of Things

MTBF Mean Time Between Failures

MTTR Mean Time To Repair

ODA Official Development Assistance

OPEX Operating Expense

RoI Return on Investment

5 Conventions

None.

6 Framework of the Recommendation

This Recommendation is intended to be accompanied by the following Supplements:

1) Capacity transfer via repeaters

2) Fibre optic cables*

3) Microwave and millimetre radio links*

4) Cellular radio technologies

5) Satellite systems

Supplements identified by * have been agreed for publication.

Further telecommunication technologies could be the subject of additional Supplements when they become available.

6.1 General requirements for low-cost sustainable telecommunications infrastructure for rural communications in developing countries

This clause identifies requirements for low-cost backhaul solutions for urban-to-rural connectivity specific to remote areas in developing countries. Figure 1 is an example of a generic network. Access networks and user terminals are not included within the boundary for costing the backhaul infrastructure.

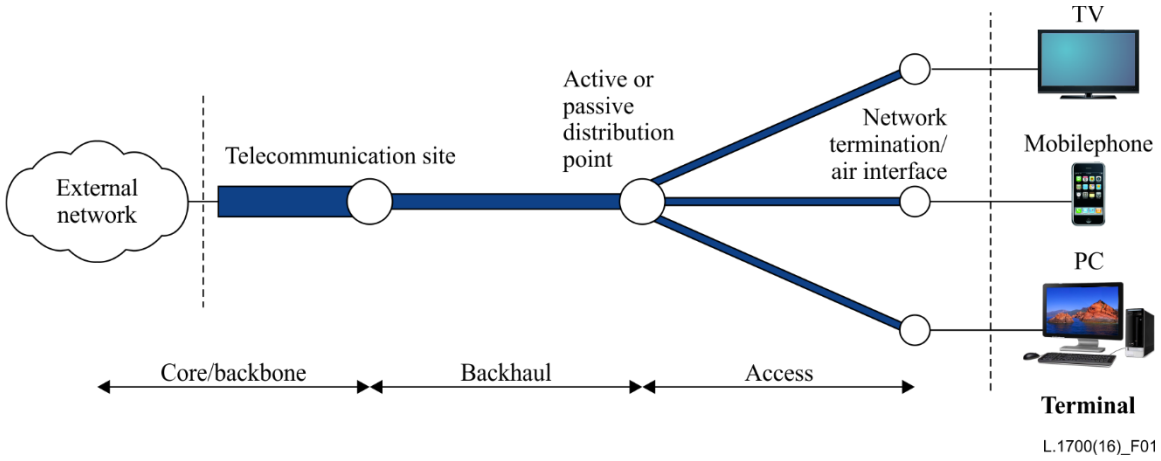

Figure 1 – Example of a generic network

It is noted that backbone network is also referred to as core network.

In many rural areas it would be difficult to generate sufficient revenue to support the introduction of digital services. It is therefore understood that other financial solutions including grant assistance, ODA loans and universal service obligations may be needed to enable services to be extended to all people. For example, if a village has the average revenue generated per user (ARPU) of one US dollar per month and has a population of 1000 people per service area with a penetration of 50% then the OPEX per service area of just USD 500 per month is available. To make the infrastructure sustainable in the service area, some financial support may be needed.

In many rural areas it has been difficult to introduce broadband services because broadband backhaul solutions have not been sufficiently affordable. However, it is strongly desired for developing countries to start implementing urban-to-rural broadband backhauls ahead of rapidly evolving IoT era in order to avoid digital exclusion and reduce the digital divide.

The following requirements have been identified for low-cost sustainable telecommunications infrastructure for rural communications in developing countries:

1. Ultimate affordability with best-effort reliability. Affordability considers both CAPEX and OPEX. The need for electric power must be included and that often greatly increases CAPEX and OPEX

2. Reliability as defined in terms of mean time between failures/mean time to repair (MTBF/MTTR)
3. High data rate with sufficient upgradability
4. High flexibility (in coverage area, number of users, bandwidth)
5. High scalability (in coverage area, number of users, bandwidth)
6. Energy-efficient power feed architecture and solutions
7. Environmentally friendly life cycle

7 Metrics for low-cost sustainable telecommunications infrastructure for rural communications in developing countries

In order to achieve sustainable solutions, sets of metrics have been developed to assess the performance of various technologies and service deployment against the reference framework. The metrics should be technology and service-agnostic and be able to be used by: policymakers in drafting policies to bridge the digital divide, operators, local communities deploying infrastructure in rural areas and equipment vendors who want to improve their product lines to include equipment that can be deployed in rural areas.

These metrics will be assessed against the generic network shown in Figure 1 which allows comparison across different technologies that could be used for rural broadband provision. Details of the specific technologies are included in each Supplement.

Whether the user terminals should be included within the boundary for costing the network technology depends on the specific service set and whether a specific user terminal has to be provided in order to access the service. For example, a mobile service cannot be used without a mobile handset, and a satellite-based service cannot be used without a satellite terminal. However, a fixed terminal such as a PC could be used to access a number of different technologies.

The following parameters should be considered for the technologies described in the Supplements.

7.1 Cost

System cost per user; cost per service area; cost per megabit.

A universal service obligation/fund could be a very important mechanism to promote telecommunication networks development in rural areas.

7.2 Energy consumption/Energy efficiency

An example is absolute power per network element, W/mbps or W/m^2.

7.3 Geographical coverage area

Square metres or square kilometres

Any limitations on the topography (e.g., mountainous terrain) that can be served should be noted.

7.4 Population coverage/Number of subscribers served

The maximum number of subscribers that can be served by the system. This is the same as the number of customers but not the same as the number of possible users (which may be higher).

7.5 Capacity

Mbps provided in total and per user.

7.6 Power feeding points

The number of power feeding systems that have to be provided per service area to operate the service. This includes the requirement for intermediate power feeding systems.

This determines whether a source of electricity has to be provided at intermediate points. The absolute power requirement per feeding point should also be specified so that its suitability for renewable energy can be assessed or whether a grid connection has to be provided.

7.7 Availability/mean time between failures

Whilst an availability of 'five nines' 99.999% is a typical target for urban telecommunications, the availability in rural communications is likely to be lower. To achieve 99.999% would incur unrealistic costs. Compared with no service at all a useful target would be 99% based upon the assumption that a break in a rural location may occur perhaps once a year and be repaired in approximately three to four days on average.

However, it must be noted that natural events may damage the backhaul infrastructure (optical cables or wireless antennas and repeaters) that connects extremely remote areas through impervious areas which may need many days before restoration thus exceptionally reducing the availability.

7.8 Protection against environmental impacts (system lifetime)

Environmental impacts include potential water and/or rodent damage. There could be a balance between any additional OPEX and CAPEX as this depends on whether sufficient protection is built in at the start or whether the system relies on being repaired later (e.g., a thicker, more costly (armoured) cable could be installed at the start or the cable could be repaired when it is damaged). For a low-cost infrastructure, the CAPEX should be as low as possible to make it affordable, but there may then be additional costs later to improve reliability/resilience.

7.9 Scalability

Ability to add a new user to a network without significant extra (other than incremental) costs. Is there a uniform or a logarithmical incremental cost to add a new user from (say) 10 – 10,000 users?

7.10 Skills requirements

The installation and maintenance of equipment in rural areas may require human resources which are outside the control of typical telecommunications operators in urban areas. To enable this, minimum training of appointed volunteers may be needed and this should be available online. The infrastructure and network elements should therefore be designed to require only minimum skills to install and operate. This will keep costs low and reduce the time to repair.

Appendix I

Examples of metrics from developing countries

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

This appendix contains some information collected mainly from developing countries on the low-cost solutions for use in rural areas in developing countries.

I.1 Affordability requirements for optical cables for direct surface application (Examples)

CAPEX: the World Bank funded USD 5,827,978 through regional communications infrastructure program (RCIP) to 316 villages throughout Tanzania (2013) for the provision of basic voice telecommunications services. After adding operators investment, average CAPEX was ~30,000 USD/village.

OPEX: Currently in Tanzania, the average revenue per user in rural areas is around 1 USD per month which is extremely low compared to urban areas in developing countries or the national average in developed economies.

I.2 Cost of civil works for conventional optical cables, examples

Cable cost: ~1000 USD/km

Civil works:

– 70,000 USD/km (Developed country): Use of large underground pipes and manholes
– 20,000-30,000 USD/km (Developed country, aerial wiring with poles at every 35 m, excluding the cost of poles)
– 30,000-40,000 USD/km (Developed country, mini-trenching and/or directional drilling between manholes)

I.3 Cost of civil works for the cables for direct surface application

– Cable cost: ~2,000-4,000 USD/km.
– Civil works: < 500~ US/km by shallow burial using handy pickaxes that varies with terrain, landform and labour per diem

I.4 An example of the cost of wireless system (equipment and civil works, developed country, 2007)

– For 18 GHz microwave system with a throughput of 100 Mbp (a pair of antennas, equipment)
– Equipment: 25,000-50,000 USD (developed country, Japan, example)
– Civil Works: 10,000-30,000 USD

I.5 Reliability requirement

An operator of a least developed country in Asia for optical cables in mountainous area (2015).

– acceptable MTBF 7-9 months
– acceptable MTTR 2-4 weeks (Summer-Winter)

I.6 Transmission capacity requirement

– 1 Gbps for the backhaul for a mountain village with a population of 1,000 (A developing country, Central America, 2013)

– US FCC broadband definition: 25 Mbps (down)/3 Mbps (up) (2015): 92% of US urban population already have this speed.

Bibliography

[b-FCC] FCC News, January 2015, *FCC finds US broadband deployment not keeping pace* https://apps.fcc.gov/edocs_public/attachmatch/DOC-331760A1.pdf

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