Wireless Communication Networks´ Planning in Underdeveloped Countries

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Abstract: *The planning of wireless communication networks in underdeveloped countries is studied for landline telephone, fixed broadband wireless access and PLMN systems via investigation and discussion of the LDC networks´ characteristic, technology selection, deployment consideration, network configuring, civil work evaluation and investment estimation. An example is embedded all through providing a general model.*

Key words: LDCs´ network planning; wireless local loop; broadband wireless access; public land mobile network

1 Telecommunication system´s deployment in underdeveloped areas is diverse featured

As released by the United Nations telecommunications agency on the World Telecommunications Day 2010, over the past 10 years mobile connectivity in the 48 countries classed as the Least Developed Countries (LDCs) had risen by 28 percent, bringing increasing mobile access to almost 250 million people; while average internet penetration in LDC bloc countries having reached only 2. 5 percent in 2010, and the web access remains well below the 10 percent target set in Brussels. At the Fourth UN Conference on LDCs in Istanbu, the Programme of Action targets include increasing the number of internet connections to 15 per 100 inhabitants by 2020 and the average phone density in LDCs to 25 lines per 100 inhabitants [1,2] .

In other underdeveloped countries and some developing areas, though access to mobile phones and internet has mushroomed in the past decades, the digital divide between economic prosperous and lagged areas, cities and remote territories is obvious and needs to be balanced.

Thus, the planning and implementation of telecommunication networks come to be a subject particularly in the national field of vision. For communities surviving from war, starvation and diseases, or live in other states of simple labouring, communication requirements primary fall in the most basic public needs of security, governmental management, core industries, sanitation and education, etc. And the telecommunication infrastructure should be deployed in distinct orientation from those with modern districts as entertainment, individual finance and conversation, etc. While most of the latter are operated in competition, most of the population of the Less Developed Countries is not telecommunication covered or in absolute poverty and the strategies building their native telecommunication system should be diverse in most of the aspects including services, target QOS, operating style and network deployment.

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Wired communication system construction would be prominent for the undeveloped world and wireless system implementation would also be the hot spot for its rapid and convinent service providing economical link realization as well as network establishment. In this paper, the wireless network deployment strategies in these areas are discussed and relative recommendations are given for the general public radio systems on three aspects of technology selection, network planning and investment evaluation, where the systems available involve wireless local loop (WLL), fixed broadband wireless access (FBWA) and public land mobile network (PLMN).

2 Adaptability analyses of wireless access technologies to the national nets

Let's discuss this by predicted services as POTS or landline phone, fixed broadband internet service and mobile service mainly of voice in the course concerned.

2.1 Landline telephone

The wireless local loop was born for a substitute of wired lines in remote areas; mountain, forest and ocean areas with light traffic; the most popular WLL system by now is CDMA based, which is superior to the LOS PMP system, GSM based system, PHS and DECT system by the character of larger capacity, expanded coverage, NLOS, packet data service and low speed mobility support. CDMA450 is a TIA-EIA-IS-CDMA2000 (CDMA-MC) system deployed in 450 MHz, deriving advantages from the CDMA2000 family and efficient lower frequency band; CDMA450 has been widely adopted in European and Asian countries and nearly 100 among them are working in WLL with products mainly supplied by Huawei and ZTE [3]. Another CDMA based technology successfully served is SCDMA (Synchronous Code Division Multiple Access), which works in TDD mode and was first designed with SDR (Software Defined Radio) and a smart antenna in narrow-band radio systems. Both WLL systems can operate in other frequency bands as 900 MHz, 1 800 MHz and 2 100 MHz, etc.

While the best WLL technologies works well for a scene with sparsely distributed subscribers fixed at even mobile, the capacity of narrow-band systems show unfitness for heavy traffic environments as urban or suburban areas. According to a CDMA2000 or SCDMA mechanism, it allows for voice capacity of up to 20 erlangs per sector/carrier with the spectral efficiency of about 8 erlang/MHz. That means, for example, implementing CDMA WLL to a district with user density about 250 per sq-km would need the frequency bandwidth of ~10 MHz. Thus a more efficient scheme is developed or happened in broadband radio access technologies supporting voice communication, as is argued later.

2.2 Fixed broadband wireless access services

WiMAX would be no doubt the wireless MAN (Metropolitan Access Network) technology for a period which originated from the IT world; it can provide tens of megabits per second of capacity per channel from each base station with a baseline configuration with large coverage distances of up to 50 km under LOS conditions and typical cell radii of up to 8 km under NLOS conditions. WiMAX air interface adopts an Orthogonal Frequency Division Multiple Access (OFDMA) for improved multi-path performance in NLOS environments [4]. The high data throughput enables efficient data multiplexing and low data latency, attributes essential to enable broadband data services include data streaming video and VoIP with high quality of service (QoS) at low cost deployment. Other advantages of WiMAX include scalable channel bandwidths from 1.25 MHz to 20 MHz, an open standards approach, "friendly" IPR structure and a healthy ecosystem. There more than 200 fixed WiMAX networks deployed all over the world. Below is the system reference diagram of IEEE 8021. 16-2004 which is the dominant protocol of WiMAX. Here the wireless links are shown in zigzag lines.

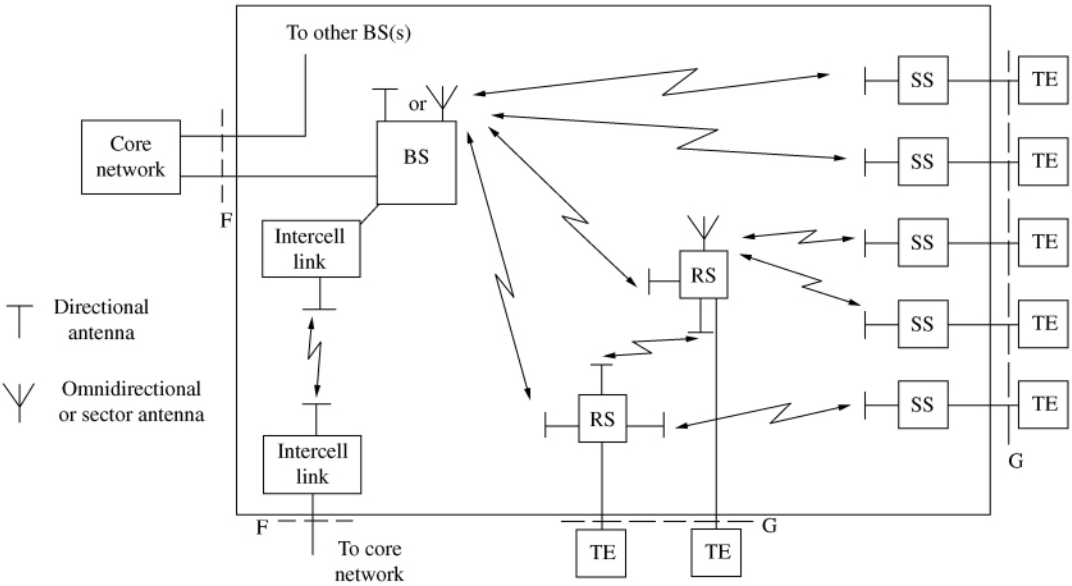

Figure 1 Reference diagram for FBWA systems [4]

FBWA systems typically include base stations (BSs), subscriber stations (SSs), terminal equipment (TE), core network equipment, intercell links, repeater stations (RSs), and possibly other equipment. BWA systems may be much simpler and contain only some elements of the network shown in the figure above. A FBWA system contains at least one BS and a number of SS units. And the "core network" elements should be the peripheral or backbone access point of IP MAN.

European and American manufactures developed their WiMAX systems aiming at broadband internet services supplying where wired links couldn´t be implemented as scheduled, voice communications not being the main concern. Whereas in many areas of developing and undeveloped countries, voices show much more necessities than data communications do, especially in the beginning stages.

McWiLL (Multi-Carrier Wireless Information Local Loop), a valuable scheme paired with WiMAX exhibits its magic. McWiLL was developed by Xinwei, who invents the SCDMA technology and offers the idea to the 3G standard TD-SCDMA. The actual key technologies of McWiLL are smart antennas including SDMA (Space Division Multiple Access) and smart MIMO (Multiple Input Multiple Output), CS-OFDMA (Code Spreading Orthogonal Frequency Division Multiple Access), TDD (Time division duplexing), dynamic modulation, dynamic channel allocation, advanced coding, and security and fraud protection. The typically applied McWiLL series of products R5 possess comparable performances with those of WiMAX; it can work with the SS mobility up to 100 km/h while taking large coverage range in frequency reuse of 1 [5]. Experiencing the SCDMA WLL development, Xinwei has designed its BWA systems to qualify as telecommunication grade voice services as well as broadband data in both system performances and interface compatibilities as interface with

PSTN of a soft switch or traditional switching core net. Besides common VoIP realization, McWiLL takes special compressed voice packets routing from a terminal to the peculiar SAG (Service Aggregate Gateway) via a base station, where SAG converts the voice to standard SIP packets. Thus, the link from SS to SAG is built to be much more efficient to carry bulky voice traffic according to the QOS standard. Figure 2 shows the McWiLL network architecture associated with the NGN core network.

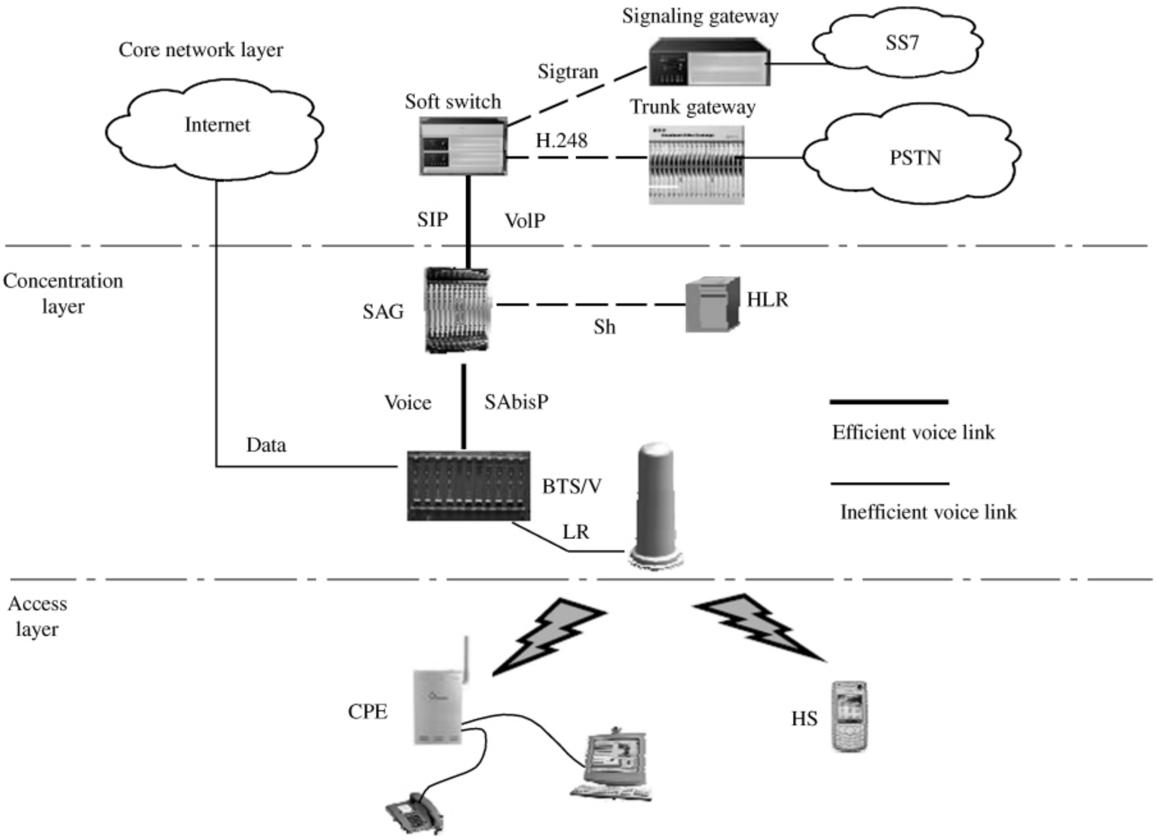

Figure 2 Illustration of the McWiLL network architecture [5]

Comparisons of the classical commercial systems of McWiLL and WiMAX are shown in Table 1.

Table 1 Classical McWiLL and WiMAX cell performances

	Unit	McWiLL (R5)	WiMAX (802.16d)	WiMAX (802.16e)
Bandwidth	MHz	5	3.5	10
Urban coverage radii	km	2 ~ 3	~5	<1
Max. throughput	Mbps	15	11.3	40
Max. specific voice service	Erl	300	70	100
Voice coding		G.711/G.729	G.729	G.729

As is shown from the Table 1:

1) With a similar coverage range with narrowband WLL, McWiLL supports a much larger voice capacity per unit frequency band as 60 Erlang/MHz;

2) The frequency efficiencies of data communication of the three systems vary from each other;

3) McWiLL takes the moderate coverage ability among the three;

4) McWiLL supports voice QOS of POTS as well.

WiMAX manufacturers as Huawei and ZTE have paid attention to system voice applications in recent years and have passed the G. 729 test in the NGN structure. While in the beginning stage of telecommunication construction in LDCs or remote areas of undeveloped countries, the principal customers are governments and enterprises with fixed services need as landline phones and BWA services, and usually a cellular mobile network would be built at the same period, or it exists already, thus we´d recommend McWiLL or fixed WiMAX (802. 16d) systems to be deployed as integrated wireless access technologies. McWiLL and fixed WiMAX being similar technologies, operators may make the decision together with products bidding on which should be adopted applying to different regions.

Moreover, both WiMAX and McWiLL can operate in almost all world acknowledged frequencies as 1. 8 GHz, 2. 5 GHz, 3. 5 GHz, 5. 8 GHz, etc. , and the frequency band choice should follow the local assignment rules. We suggest better to escape the ISM band for security, for example 2. 4 GHz and 5. 8 GHz band.

2. 3 PLMN services

The world´s PLMN networks are taking their evolvement from 2G to 3G and later LTE system, for the former as a CDMA2000 system being upgraded from 1X to 1XEV-DO or WCDMA/TD-SCDMA system being built to overlay the GSM net. For circumstances of building a brand new mobile network, every scheme becomes possible because all schemes are assigned by an ITU with multi frequency bands.

Considering the basic voice communication needs in LDC and undeveloped countries, a stable voice function is still of primary importance and the performances should be inspected with those 2G and 3G systems.

CDMA2000 standard technologies have shown outstanding capabilities in traffic influenced dynamic coverage cases, more matured performances in packet data services, and more over, the strongest compatibility between its 2G and 3G systems. The CDMA2000 1X system provides the dedicated power controlled CDMA voice services which shows both stable and comparative high spectral efficiency, and supports in Release B the maximum packet data rate of 307. 2 Kbps which is actually achievable in ~120 Kbps at most in commercial networks. The CDMA2000 1X-EvDO, being the data only system of the 3G era, claims the theoretic maximum downlink data rate of 3. 1 Mbps in Revision A, the most popular system with CDMA2000´s 3G technologies, and is proven averaged about 900 Kbps achievable in world wide commercial networks [6]. Thus, CDMA2000 tends to be an economic choice to supply acceptable packet data communications while serving voices principally. On another side, 3GPP2 organization has turned its future research to LTE joining in 3GPP route; this leads the CDMA2000 evolution to no where but another family. Although most of the evolutions even with their own series are finally implemented by setting up new BSs or substituting BSs or modules, technical supports and products´ services could easily tend to be unsuccessional on the above occasion, and roaming in and from a country may ask the mobile terminal to be a bi-mode. So, if CDMA2000 be the choice, it's suggested the operator select manufactures developing both series of CDMA2000 and WCDMA/TD-SCDMA, or could provide the evolution solutions to the LTE system.

GSM being the universal standard is supported by almost all countries with cellular networks, with at least one GSM operator. The so called 2.5G packet data transmission technology GPRS presents a less ideal data rate than CDMA2000 1X, and WCDMA or TD-SCDMA network was later built supplying higher rate packet data communication services in developed and developing countries, requiring the terminals being compatible with the 3G standard as well; and both systems are not as matured as CDMA2000 1X-EvDO and are mainly deployed in around a 2 GHz band that more sites are needed.

There were 640 million WCDMA subscribers globally by the end of 2010, nearly four times that of CDMA2000 1X-EvDO, and 99% of WCDMA networks have loaded with HSPA or HSPA + facilities with theoretical downlink peak rate up to from 14.4 Mbps to 21 Mbps; respectively [7]. TD-SCDMA is believed less matured and is deployed mainly in China with its biggest operator CMCC. TD-SCDMA first reveals and devotes to solve the WCDMA system paradox of near-far effect or breath effect and first adopts a smart antenna in the cellular network in a TDD mode which express advancement closer to BWA systems, and enable the system working in non-symmetric band mode. Being the recently commercially matured system, TD-SCDMA is worthy to be comprehensively surveyed at the product bidding time.

In a word, no choice is perfect. We'd recommend the CDMA2000 scheme deployed if voice and domestic communication would be the primary service; for circustances with considerable data traffic and international roaming needs, the GSM + UMTS scheme would be preferred. While the 3G systems become the hot spot in recent years' construction and operation, GSM is still the most popular system best supporting world wide roaming. Furthermore, either 3G network would evolve to the LTE system next stage, no matter what technologies the 2G and 3G systems adopt.

In addition, final decisions could be made along with the system equipment bidding as well.

3 Deployment strategies of wireless accesses

From the above analyses and predicted development schedule, strategies and principles of wireless accesses are suggested as the following.

1) Landline phone and fixed broadband internet communications are partially supported via radio by integrated access broadband base stations of McWiLL or WiMAX; the wireless coverage continuity is unnecessary.

2) Subscribers to be implemented with BWA CPEs (Customer-premises equipments) when wired links fail are proposed in three categories, priorities in sequence.

(1) Core government organs, national defence and social security organs as militaries, police, firehouses, hospitals etc.; Most BWA systems built would be replaced with wired links later; the CPEs can be reused in other spots or be kept as backup links.

(2) Colleges, schools, general government organs, important enterprises, embassies, transport hubs etc.; Part of these spots would get wired connected instead of following stages, public spots as campuses, transport hubs in water areas etc. would keep radio accessed.

(3) General enterprises, inhabitants, hotels, shop-

ping centers, markets, etc.; The BWA devices here could be placed permanently unless the subscribers need a change.

3) Scenarios of BWA systems would be implemented in the LDCs and generally include four types:

(1) As the country´s communication infrastructure is in serious deficiency, even national important organs couldn´t be telecommunication-equipped completely in the initial stage, BWA thus would be the temporary method.

(2) For satellite towns, isles, remote cities or factories, or sparsely located subscribers who lie beyond the wired access network built, BWA may serve for some years and be partially reserved.

(3) For buildings and roads involved in city rebuild, related subscribers would better be wireless accessed.

(4) Public spot areas, residential areas and historic sites might be wireless accessed all along.

4) PLMN is to be built in the same cities along with the IP MAN and NGN networks, but in a continuous covering mode and extending ranges. It would be as seamless as possible in urban and suburban areas, town and village centers, main roads connecting the covered cities and busy river lines.

5) BWA and PLMN BSs are preferred to co-located.

3.1 Wireless access network configuring

3.1.1 Broadband wireless access

1) System parameters

The integrated broadband wireless access system for a project is defined with parameters in Table 2 involving the following considerations.

Table 2 BWA system parameters

	Voice		IP data	
Traffic supplied via BWA	50%		30%	
BH traffic per subscriber	0.03	Erl	512	Kbps
Overbooking factor	——		20	
Cell radii	4	km	4	km
Cell capacity	60	Erl/MHz	3	Mbps/MHz
Average subscribers accessed through 1 CPE	30		15	

(1) A great portion of a BWA system is supposed to be set up as temporary links supplying services to governments and enterprises at the beginning, due to the almost vacant telecommunication resources; and while the services extend to suburban and more inhabitants and small organs at the second stage, wireless access becomes the economic choice for clients. Broadband internet application would be much less popular than telephone due to the availability of computer or laptop, and the customers would be prominently organizations in need of internet communications for work, which would ask more reliability than cost-efficiency. Thus, we may propose some percentage of the fixed voice traffic is carried via BWA (e.g. here 50%), and similarly e.g. 30% of the broadband internet customers are connected this way.

(2) The busy hour (BH) traffic per subscriber is estimated as e. g. 0.03 Erl voice and 512 Kbps broadband data throughput (T) per broadband customer. The convergence ratio is to be set as experience, e. g. 20:1.

(3) The coverage range of the BWA site should be estimated according to the target terrain, via linking budget or following convention, seeing to specified cases. For example, many urban and suburban areas of most LDCs' cities appear as congestions of buildings no higher than 25 m, sporadically dotted by some high architecture, as is shown in Figure 3. This is favorable for radio transmission and we set the radii of BWA cell as 4 m, which is a bit further than that in cities with bundles of high-rises.

(4) The cell capacity is set to the average level of BWA products, where 60 Erl or 3 Mbps is acquired in voice or data only mode, respectively; and the two services are suggested to be able to share the cell resource.

(5) The customer premises equipment of the project should support RJ11 and Ethernet ports. Part of the terminal subscribers is supposed to communicate by sharing the CPEs installed nearby; for example the CPE of an office building, an enterprise, or a dormitory block; else where BS signal are good enough to communicate directly between BS and SS, terminal with receiver is all we need. We may believe the former holds the most due to the main customers' identity of the organization where a small switch is often used. The probable end subscribers converged to 1 CPE thus could be expected, always with service and stage's differentiation, as is shown in the instance below.

Figure 3 Local overlooks of two cities in some LDC

2) System coverage and capacity evaluation

Covered areas and subscribers are demonstrated according to the above analyses, predicted project scales, stages when the project would be deployed, and the cities´ specialties. Table 3 shows a case for City *A* project, where system virtues are set and evaluated, respectively.

Table 3 Target range and subscribers of BWA WLL for fixed services

Fixed services´ attribute Cities	Landline voice				Broadband data			
	Target range		Target subs	BH traffic	Target range		Target subs	BH traffic
	%	sq-km	–	Erl	% Vs. voice	sq-km	–	Mbps
City *A*	10%	997	234389	7032	40%	399	8094	207

The target range represents total areas covered by BWA BSs. As in the above case, with a large pratition of rural and suburban areas involved in City *A*, 10% of the total range is planned to be voice available after stage *N*, and 40% of the range would be covered by a BWA system where broadband data services are reasonably desired within the voice covered areas, and part of BWA BSs would carry broadband data. The consideration of city specialties usually include its major industries, population distribution and density, subscriber characteristic, the city´s development plan, etc.. For instance, in heavy populated cities with prosperous trade and business, a much higher coverage rate should be set. According to a practical situation, the wired and wireless accessed regions may be overlaid, or customers accessed by the two modes may be interlaced geographically.

3) Network configuring

To meet the above target coverage and traffic capacity, the BWA network shall be planned and configured by stage, the case of some phase is shown in Table 4. We need 32 base stations for City *A*, with ~13 of them carrying broadband data services by average 2 cells per station; those taking voice services are mostly Omni enough. Some extra partition of the total base stations may be taken into account for uncertain factors.

Table 4 BWA WLL network configurations

Fixed BWA configuration City	BSs total	BSs with data traffic	Voice Vol.	Data Vol.	CPEs total	CPEs with data traffic
	–		Erl per BS	Mbps per BS	–	
City A	32	13	220	16	7 813	540

Fixed BWA configuration City	Required cells in 5MHz TDD BW			T _ BS-IAD		T _ BS-WAN
	for voice only BSs	for BSs with data traffic	Required cells	for voice only BSs	for BSs with data traffic	for BSs with data traffic
	per BS		Total	Mbps per BS		
City A	1	2	45	15.7	38.5	22.8

Cells needed per station here are estimated under the assumption of a system of 5 MHz bandwidth, TDD mode, which is one of the most popular schemes in a BWA world. For other cases, the cell amount can be easily converted. Cells per station express the radio resource consumption the network requires and also the capacity or services it may afford. While the figure depends on frequency efficiency varying from one product to another, we'd evaluate products comprehensively taking it as one indicator which might be a trade-off to other factors. For example, a system with frequency reuse of 1 would need 5 MHz BW in any circumstance and expand through sectorization; one with frequency reuse of 2 would need $\sim 2 \times 5$ MHz BW for a standalone base station with 4 cells, etc.

There will be 7813 CPEs installed for City A as estimated, and it's usually suggested that operators shall supply terminals like telephone, fax, hub, possible wireless repeater as well as CPEs.

The throughput between the base station and integrated access device (IAD) may be briefly estimated by BS types concluded as in Table 5, ignoring the departure of voice and data to different core domains. In Table 6, the scale of the City A BWA system is summarized in base stations of capable types, cells and CPEs.

Table 5 Typical maximum throughput and power consumptions of the BWA WLL system

BWA WLL BS type	Uint	*A*	*B*	*C*	*D*	*E*
Cells/BS	–	1	2	3	4	6
T _ max	Mbps	15	30	45	60	90
BS power consumption	W	250	500	750	1 000	1 500
Phase *N* end scale	BS	19	13			
CPE power consumption	W	5	5	5	5	5

Table 6 Scale and workload of the BWA WLL system

The scale of fixed BWA WLL City	Project end scale					
	BSs with *n* cells			BSs	Cells	CPEs
	n = 1	*n* = 2	*n* = 3	Total		
City *A*	19	13		32	45	7813

Moreover, there always are OMC elements with the BWA system, and might need extra controlling and protocol transforming elements like some gateway according to manufacture features. We may believe the featured elements are included in the base stations´ network, and suggested the number of OMCR be equipped according to product specification and coverage distribution.

3.1.2 **PLMN radio access**

1) System parameters

The busy hour voice traffic per subscriber may set according to the detailed condition or conventionally as 0.02 Erl for instance. Also, the amount of the PLMN subscribers taking packet data services (PS) and their busy hour data throughput should be predicted, and in the example below it´s supposed that 30% of the PLMN subscribers would take PS with a busy hour throughput of 150 bps per subscriber.

Then from the radio propagation condition discussed before, the average site interval may be set considering the traffic density, for example here it is set to average 2.5 km for City *A* where the traffic density is no more than 10 Erl per square meter. Actual implementation would distinguish this from one environment to another, as urban and suburban, harbor and downtown, etc., and the BS antenna height would vary relevantly. Cell splitting could be performed in later phases if heavy traffic is loaded.

Table 7 PLMN system parameters

Parameters	Value	Units	Remarks
BH voice traffic	0.02	Erl/sub	
BH packet data traffic	150	bps/sub	
PS popularization	30%		
Average site interval	2.5	km	

2) PLMN base station network configuring

PLMN asks seamless coverage in a broader region than BWA´s where human activities exist ordinarily, besides dwelling spots. And the target ranges of PLMN are planned in large proportions as described in Table 8. City *A* experiencing the first stage construction is supposed to achieve 100% area coverage.

For convenience, we estimate the scale of RAN by the CDMA2000 1X system, no to bothering on choosing other schemes while the cost-efficiencies are just so among comparable technologies.

Four types of CDMA base stations may be used as defined in Table 9 with typical configuration, Abis link and power consumption requirements. All BSs are just planned as 3-sector.

Table 8 PLMN RAN configurations

PLMN RAN City	Target range		Target subs	BH voice traffic	BH data traffic	BSs amount
	%	sq-km	-	Erl	Mbps	-
City *A*	40%	3 986	431 694	8634	19.4	737
PLMN RAN City	BS cfg			Abis link		
	Carriers	Sectors	Cell cfg.	E1 per BS	Total	
City *A*	1	3	1/4	1	737	

For the first stage construction of City *A*, a single carrier is enough to supply the predicted traffic, and altogether about 737 BSs should be installed for the case.

Table 9 CDMA base station types

PLMN BS type	Carrier	Sector	Cell cfg.	Voice vol.	Data vol.	Abis link	Power consumption
–	–	–	–	Erl	Kbps	E1	W
A	1	3	1/4	7	17.1	1	750
B	1	3	1/2	14	34.2	1	750
C	1	3	1	28	68.4	2	750
D	2	3	1	56	136.8	3	750

Besides, a few skyscrapers and blocks would need indoor coverage systems where wireless link loss from an outdoor base station is too severe to keep the service inside prominently owing to the penetration loss of the tall or large buildings. For example, we proposed ~ 40 such buildings should be set up with indoor coverage systems by the first stage. Hence we´d take into account the 40 sets of indoor distribution systems extra; while the base stations´ function is believed included in former configured systems, that is some base stations or some carrier and sectors are used specially as indoor signal originators.

3) PLMN BSC/PCF configuring

The popular industrial BSC products working with IP bearers can support voice traffic up to ~50,000 Erl and 2,000,000 subscribers, thus may support about 2,000 carrier. sectors configured at maximum capacity. The base station controllers´ geographic topology or BSC zones should be set according to the BSC product capability and the allocation of MGW elements connected with BSC at the A (A2/A5) interface, and the PCF (packet control function) elements are usually deployed matching BSCs´ allocation. The exampled BSC/PCF configuration is suggested in Table 10. Here City *A* is divided into two BSC/PCF regions, and share one of them with City *B*.

Table 10 BSC/PCF configuration

BSC/PCF	City	Subs	Erl	TRX	Abis IF Mbps	A IF link E1	R-P IF Mbps	Power consumption /W	Bureau Site
1	City *A* zone-1	237 432	4 749	1 215	810	227	21	5 000	City *A*
2	City *A* zone-2 / City *B*	247 903	4 958	1 266	844	237	22	5 000	City *A*

Traffics between elements relevant to RAN are laid out in Table 10 and Table 11. Among the interfaces, Abis IF may adopt E1 or FE port see to the bearer mode; A and Ater (A3/A7) IF may adopt E1 as in the case, STM-1 or fiber ports according to the IF traffic, the limit of ports of equipment and the civil work ability; R-P (A10/A11) interfaces connecting PDSN here should take FE ports and cat-5 or cat-6 cables.

Table 11 Ater interface links in E1

Ater E1	BSC1	BSC2
BSC1		23
BSC2	23	

In Table 10, bureau sites of BSCs are also proposed, and corresponding power consumptions of each BSC/PCF is advised.

Finally, terminals should be considered as part of the system constitution in a terminal customized or service customized mode, which is popular to overseas operators.

3.2 Wireless access base stations´ assembly and civil work requirements

With the total PLMN BSs and BWA BSs planned, it´s almost no problem for the two systems to be co-located and share civil resources.

Thus, the sites´ power consumption and transfer throughput shall be considered in three cases: sites with PLMN BS only, sites with PLMN BS & BWA BS with voice traffic and sites with PLMN BS & BWA BS with voice and data traffic. The total requirements may be shown in Table 12. Though we estimate the Abis transfers information in E1 links, most BSs equipment today support Abis transmission in the IP mode and can be connected through a FE port as well as E1 port, this is a matter to be discussed in optioning of BS and IAD equipment.

Telecommunication towers are supposed to be built with the project if necessary to excluded the possibility sharing existing towers of other operators. We usually suggest a portion of total sites that would need new towers (here 85%), as else might have its antennas pole-mounted on the roofs of buildings. Antenna height to floor is commonly ~30 m in urban and ~40 m in suburb for typical cases.

For sites with PLMN BS only, one working platform is needed for antenna installation; for those with BWA BSs also, at least two platforms are required. Considering the possible joining of microwave and evolved PLMN systems in the future, one more platform is preferred. For the platform of a BWA system, 0 ~ 360° installations is required for those with 4 or 6 sectors in one BS; outstretched pole-mounting is required for BSs of Omni cell whether for BWA or PLMN system; styles for PLMN would be 3-sector BS with 3 directional antennas which can be attached to the tower. Finally, a GPS antenna and tower mounted amplifier might need to be installed, which usually is an ordinary case for telecommunication sites.

4 Investment estimation of wireless access systems

Investments of this part include those of wireless access system equipment such as base stations involving antenna and feeder suits, base station controllers, OMCRs, indoor coverage distribution systems, and exclude those of civil works.

The investments are estimated in equipments´ cost, installation fee and the expending like management consumption, network design payout, etc. The equipments´ cost is appraised in per cell or per carrier and sector cost, or per OMCR integrated value taking into account the system hardware and software, installed elements and testing tools, transport cost, insurance and training price, etc. No installation fee is counted for PLMN customized terminals.

Detailed estimation methods and related ratios are explained in Table 13 for every item, following the case of city, where the total investment of its wireless access systems is evaluated.

Table 12 Wireless access base stations´ assembly and civil work requirements

BSs assembly and civil work requirements City	Sites with PLMN BS only			Sites with PLMN BS & BWA BS with voice		
	# of sites	Power consumption	Throughput to IAD	# of sites	Power consumption	Throughput to IAD
	–	W per site	Mbps per site	–	W per site	Mbps per site
City *A*	705	750	2	19	1000	17

BSs assembly and civil work requirements City	Sites with PLMN BS & BWA BS with voice and data			Towers proposed to be built
	# of sites	Power consumption	Throughput to IAD	
	–	W per site	Mbps per site	–
City *A*	13	1250	32	626

Table 13 Wireless access systems´ investments

Item	System element		Unit	Amount	Unit price	Total price
Equipments	BWA	Base stations	Cell	45	P1	T1 = 45P1
		CPEs, terminals and accessories	Set	7813	P2	T2 = 7813P2
		OMCRs	Set	1		T3 = 30% (T1 + T2)
	PLMN RAN	Base stations	Sector & Carrier	2481	P4	T4 = 2481P4
		Indoor distribution systems	Set	40	P5	T5 = 40P5
		BSC/PCFs (including OMCRs)	Set	2	P6	T6 = 2P6
	Subtotal 1					S1 = SUM(T1:T6)
	Installation fee					I1 = S1* R1
	PLMN terminals		Set	431694	P7	T7 = 431694P7
	Subtotal 2					S2 = S1 + I1 + T7
The else:	management, design, etc.					I2 = S2* R2
	Total investment					S2 + I2

5 Conclusions

The planning of deploying wireless communication networks in underdeveloped countries is investigated step by step in this paper. Wireless landline telephone, fixed broadband wireless access and PLMN services are discussed in turn with their mainstream technologies, adaptability to LDC telecommunication networks and the system configuring and project estimation method. By an embedded example for every step, the detailed working process is presented as a reference model for LDC wireless communication networks´ planning.

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