BJNet: Another Way to Build a NREN

Marc Lobelle[1(✉)], Norbert Hounkonnou[2], Firmin Donadje[3], and Victor Oyetola[4]

[1] Louvain School of Engineering, ICTEAM, Université catholique de Louvain, Place Ste Barbe, 2, 1348 Louvain-la-Neuve, Belgium
marc.lobelle@uclouvain.b
[2] ICMPA, Université d'Abomey-Calavi, 072 BP50 Cotonou, Benin
norbert.hounkonnou@cipma.uac.bj
[3] Forces Armées Béninoises, Cotonou, Benin
cofindo@gmail.com
[4] SPTIC, Université d'Abomey-Calavi, Cotonou, Benin
victor.oyetola@uac.bj

Abstract. This paper presents the way a gigabit NREN (National Research and Education Network) covering the whole country of Benin and that will connect over twenty university centers is being built using mainly local unused infrastructures and local permanent staff already paid by the State of Benin (predominantly personnel from the Université d'Abomey-Calavi, UAC, in Benin and from Benin Armed Forces). The necessary additional equipments were provided by a relatively modest ACP (African, Caribbean and Pacific Group of States Organization) project mainly funded by the EU. The necessary expertise was mostly provided by a Belgian university, Université catholique de Louvain (UCL), a Beninese university, Université d'Abomey-Calavi (UAC), signal officers from Benin Armed Forces (FAB) and the Belgian NREN, Belnet.

Keywords: NREN · Internetworking · Network design and implementation · Development · Campus network · Civil-Military cooperation (CIMIC) · Development policy

1 Introduction

Every country should have a National Research and Education Network (NREN). These networks are much more than yet another internet service provider. Beside providing access to the internet at large, they are intended to connect with a wide bandwidth all universities and research centers in the world. They enable the use of MOOCS [5, 8] at low cost to higher education students and researchers worldwide. They enable sharing huge amounts of research data such as those of the CERN. Currently, developed countries have their NRENs. The situation is different in developing and emerging countries. Lucky ones have a NREN; some have nothing and others have still just a name, sometimes with a director or a steering committee, but neither infrastructure nor service.

When the first NRENs where created in developed countries, some 25 to 30 years ago, they were also just small organisations managing a few leased lines of a few tens of kbps, but they grew and are now managing, for their users, real information highways,

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big data centers and many services such as authentication services, eduroam, clouds, software download mirrors etc. [2, 9]. They manage budgets in some cases of up to tens or even hundreds of millions of Euros a year for maintaining and developing the services and keeping up with the increasing demand [3].

Today, the needs for NRENs in developing countries are not different from those of developed countries but they cannot afford spending the same amount of money and, if they were using the same solutions, they would actually need more money because they do not just have to maintain the network and the services but they must build everything from scratch. Another approach is thus needed and has been demonstrated to be feasible by the BJNet project.

Section 2 will present the context of the BJNet project.
Section 3 will present the problem statement of building a NREN for Benin.
Section 4 will present the BJNet strategy to solve this problem.
Section 5 will discuss discuss synergies with the RERBénin project
Section 6 will discuss political issues.
Section 7 will summarize and conclude

2 Context of the BJNet Project

2.1 University Networking in Benin 2004-2010

In 2004, there were only two public universities in Benin, the Université d'Abomey-Calavi (UAC) close to Cotonou in the South and the Université de Parakou (UNIPAR), in the North. They had respectively some 30.000 and a few thousand students, but there was no campus network. On the campus of UAC there was (andthere still is) the Centre Numérique Francophone de Cotonou (CNFC), financed by the Agence Universitaire de la Francophonie (AUF), that was connected to internet and had a LAN with a few computer rooms. There were lines linking the CNFC to therectorate and a few faculties. In UNIPAR, only the rectorate was connected by radio to a local ISP, BorgouNet.

In 2006, the Belgian "Commission Universitaire pour le Développement" (CUD) financed a first extended campus network for the UAC under the coordination of prof. Hounkonnou and prof. Lobelle. This project was conditioned on the UAC subscribing at own cost to an internet connection (modest: 6 Mbps) and recruiting on the university payroll the staff to manage and operate the network. The CUD would bring the funding and the expertise to design and build the network.

Most buildings of the Abomey-Calavi Campus were connected to the the internet access point of the university through a shared radio network connecting all the buildings via outdoor 802.11a access points with sector antennas. Remote campuses in Dangbo (IMSP: Institut de Mathématiques et de Science Physique)), Porto-Novo (ENS: Ecole Normale Supérieure, FLASH: Faculté de Lettres, Arts et de Sciences Humaines), Cotonou (ENEAM: Ecole Nationale d'Economie Appliquée et de Management, FSS: Faculté des Sciences de la Santé) and Ouidah (IRSP: Institut Régional de Santé Publique) were connected through point-to-point 802.11a links with 30 dB antennas located on top of up to 40 m high guyed masts. The whole infrastructure provided a shared

bandwidth of some 40 Mbps to the buildings of the main campus and 10 to 20 Mbps to each of the remote campuses, located at distances ranging from 10 to about 35 km. The quality of the long distance connections could be degraded by climatic conditions (heavy rain, thunderstorms).

In 2008 the ACP (African, Caribbean and Pacific) organization launched a call for projects to be funded mainly by Europe Aid in the framework of the @CP-ICT program. The authors submitted a project, called BJNet, aimed at reinforcing and extending the intercampus network under construction for UAC, in order to increase its capacity and also reach the campus of Lokossa, too far to be reached without relay from the nearest other site of UAC (IRSP-Ouidah), and the campus of the university of Parakou. The project was to build a network based on both the experience of building the intercampus network of UAC (based on radios with high gain antennas on 40 to 60 m high guyed masts) and the Belnet NREN in Belgium. The interesting particularity of Belnet is that it is not restricted to higher education and research institutions but that it is a State funded network open to all administrations, as long as they bear the additional costs induced by their use of the network. This use policy has three advantages: the first two are common to Belgium and Benin while the last one is specific to Benin.

1. The more administrations use the network the less the State will be prone to cutting in the budget of the network.
2. Because of savings due to the scale of the network and its large number of users, and the fact that traffic between sites in the country does not have to be routed through the internet at large, the use of this public network for connecting administrative sites is much more cost effective than renting leased lines or through private internet service providers.
3. By involving, in the network, other administrations than higher education, the number of possible sites for locating guyed masts for radio relay increases dramatically. Indeed, the reason why it had not been possible to connect Lokossa to the UAC network was the lack of a suitable site in the town of Comè, where the UAC does not own any premises. The maximum budget for these ACP projects was one million €, of which 85 % would be borne by the EU and 15 % by the partners. The BJNet partners were, in Belgium, Université catholique de Louvain (coordinator) and Belnet, and, in Benin, Université d'Abomey-Calavi (co-coordinator), Ministry of Higher Education and Research (MESRS), Ministry of Economy and Finances (MEF) and Ministry of Communications (MCTIC). The Beninese Armed Forces (FAB) also expressed interest in using the network and contributing to its implementation without being a formal partner.

For various reasons, the project was only accepted and allowed to start two years later, in September 2010. In the meantime huge changes had occurred in the Beninese higher education landscape: the number of campuses, called "Centres Universitaires" (CU) created or planned had been increased to 22, from Kandi and Nattitingou, in the North, to Savalou and Aplahoué in the West or Kétou and Adjara in the East: the new centers were spread all over the country. Many had little staff and thus needed facilities for distance learning. As it had been planned in 2008, the network would only have satisfied a small part of Benin's higher education needs.

2.2 Public Networking Resources in Benin at the Start of the Project

Networking resources in Benin are owned by the public operator Bénin Télécoms and its subsidiaries such as Kanakoo and by mobile operators (Bell Benin, Glo, Libercom, Moov and MTN). All have a long distance infrastructure based on microwave links (point-to-point radio links) between telecommunication towers. Bénin Télécoms also has optical fiber cables along 3 axes: one along the southern coast, from Togo to Nigeria, one South-North from Cotonou, on the coast where the SAT3 undersea cable lands in Benin, to the border with Niger in Malanville, via Bohicon, Parakou and Kandi. The third link is from Parakou to Porga on the border with Burkina-Faso, near Tanguiéta. This cables passes through the town of Nattitingou.

The short distance infrastructure used for data connections and internet access consists of one-to-many last mile radio links, adsl connections, and leased lines.

3 Problem Statement: A NREN for Benin

The NREN for Benin had to interconnect all University Centers (CU) in Benin. Other public sites could be connected if the concerned administration contributed at least enough to cover the cost of their connection. Indeed the European funding funding was dedicated to education and research institutions.

The most interested "administration" was Benin Armed Forces (FAB) which lacked a reliable territorial communication infrastructure, (as consequence, it could take up to a day for the headquarters in Cotonou to be warned on a border incident during the rainy season). The FAB were also interested by the possibilities offered in the field of telemedecine between military hospitals: if the military hospitals could be connected through a suitable networking infrastructure, the FAB could get help in the field of telemedecine from the US army. Moreover, Benin Armed Forces have difficulties to deploy modern human resource management tools as they don't have access to a territorial communication infrastructure.

Regarding the University Centers, they could, broadly, be divided into two categories: big campuses with thousands to tens of thousands of students and small campuses, with tens to hundreds of students. The first category counted fortunately only 3 members and the State of Benin was planning to connect two of them with optical fiber cable to the Bénin Télécoms exchange closest to their campus: Abomey-Calavi and Parakou. The third one is in Cotonou, namely the Faculty of Health Sciences. These three should be connected to BJNet with optical fiber cable; for the others, a 100 Mbps radio link is acceptable.

The BJNet backbone should be optical and at least 1 gigabit. One might argue why not more bandwidth? Janet, the UK NREN uses 40 Gbits links since 2007 [4]. The reasons are simple:

1. we want affordable technologies: cheap to buy, cheap to install, cheap and quick to replace in case of malfunction, easy to upgrade;
2. an earthen dam can hold huge amounts of water but as soon as a rivulet gets across through a rat hole or passes on top, the dam will be quickly destroyed. This is what

we want to do: get a significant rivulet of information across between higher education institutions and when it will not be enough anymore, it will be much easier to find funding to upgrade the network than to set it up initially, at least if it has been designed to be easily upgradable.

Another element to take into account was that several of the guyed masts built in 2006 had collapsed before 2010. Apparently some contractors of cooperation projects consider that the only purpose of a project is to provide some employment and some benefit in the target country, that nobody is interested any more in the results of a project after its implementation: the guyed masts were not adequately protected against corrosion. A closer analysis revealed that Benin has no hot zinc coating facility and thus locally built masts will rust at least at the weldings, without heavy maintenance work. Therefore imported masts, manufactured in a country where quality control matters, had to be used.

4 Resolution Strategy

The change in size of the problem to be solved, between the time the project was submitted and the time it had to be implemented imposed a choice between with 2 options:

1. implement the project according to the original plan: find a guyed masts manufacturer abroad and let a local contractor replace the old rotten masts and set up a chain of masts between Abomey-Calavi and Parakou and build a network serving only a few University Centers, and which soon would become obsolete.
2. Find available local resources (workforce, existing unused infrastructures), if possible at no cost, and use the european funding to buy what cannot be obtained that way and try to build a network corresponding to the current needs but, equally, easily upgradable.

The second option was selected.

4.1 Infrastructures

Fortunately for the project, many fiber pairs in the cables set up by Bénin Télécoms (BT) were found to be unused. The use of fiber pairs rather than single fibers was planned because, for bidirectional traffic, optical equipment was cheaper when using fiber pairs than when using single fibers, and because fiber pairs can obviously be upgraded later to twice the capacity of single fibers.

Allowing BJNet to use such “dark” (unused) fibers can make sense for Bénin Télécoms. Indeed, internet access is currently offered at reduced cost to universities by Bénin Télécoms and, if this traffic were moved to BJNet fibers, that bandwidth could be sold to other customers paying the full fare, at a higher profit for Bénin Télécoms. Besides, a renting tariff for the dark fibers can be negotiated later between Bénin Télécoms and the Government of Benin. The equipment to be added in each BT exchange in order to build the BJNet backbone from these dark fibers consists only of a box including a small

router and fiber interfaces appropriate for the distance to the next exchange (plus whatever is needed to connect local user sites). When the exchange is just a relay for BJNet and the distances on both sides are short, a simple optical patch cable between the two cable heads is enough.

The active equipment uses only little power, typically a few tens of watts, and can be powered by the battery backed 48 VDC power supply that is standard in any telephone exchange. The total power used in the backbone including links to the user sites is only 1.2 KW. The cost of that power should be included in the renting agreement for using the dark fibers. Obviously, the equipment to be placed in the exchanges has to be bought by the project with European funding. It was selected to be cheap but offer all the functionalities needed in a high performance TCP/IP wide area network. MIKROTIK equipments were selected. Besides satisfying the above requirements all their devices use exactly the same software. This simplified the training of operational staff.

For the large University Centers of Abomey-Calavi and Parakou, the connection to the BJNet backbone can similarly use a pair of fibers in the cable planned to connect the campus to internet via the BT internet infrastructure.

For the smaller sites, with more limited needs, radio links are enough. Cheap radios allowing a bandwidth of 100 Mbps were selected (also MIKROTIK). They can be used for both small and long distances. If needed, some links may be upgraded later with higher bit rate radios. The radios are used with high gain (30 dB) wide band (covering the entire range of 5 Ghz) antennas. This allows the selection of cheap radios, mass produced for 802.11a links, which are tuned to a reserved military channel out of the standard 802/11a bands. Since high gain antennas reduce interferences with devices located out of the point-to-point link, it was decided to use the same radios and antennas for all the radio links. All these devices were bought using the EU funding.

5 Ghz radios need line of sight links with no obstacles close to the line of sight (the 1st Fresnel ellipsoid should be free [7]). This implies locating the radios and antennas higher than the obstacles taking into account the earth curvature for longer links. Thus, masts or towers are needed. Since the backbone fiber network of BJNet runs through BT exchanges, one of the ends of each radio link to a BJNet user site must be located above this exchange. This provides the opportunity to use other existing and often available resources. Indeed, optical fibers are relatively new in Benin (some 20 years). Before the availability of fibers, long distance links between exchanges were implemented with microwave links needing their antennas to be located, like ours, on communication towers, high above the BT exchanges. Therefore, there is a telecommunication tower above each BT exchange, sometimes almost empty, often moderately filled with antennas connecting Bénin Télécoms clients, such as bank branches etc. In most instances, there is enough free room on these towers to add a few radios and antennas to connect BJNet user sites. Again, the use of room on these towers may be included in the renting agreement to establish between the Beninese State and Bénin Télécoms.

Only the radios, the antennas and the cables to connect them are thus needed for the BJNet user links and must be bought, but, on the backbone side, the radios can be placed on the existing BT telecommunication towers.

On the user side, the same radios and antennas are used, and a small router is used indoors to isolate the user's local network from BJNet. Of course, here too, the radio

must be higher than the obstacles, but because these sites are often not very far from the BT Exchange, rooftop masts are generally enough. These masts too were bought using the European funding. Apart from the sites discussed above, which are close to fiber fed BT exchanges, three other types of user sites must be considered

1. the big Cotonou site of the Faculty of Health Sciences,
2. the small sites which are too far to be connected using a rooftop mast but reachable if a guyed mast is erected in their premises,
3. the small sites that can only be reached through a chain of several radio relays.

For the Faculty of Heath Sciences (FSS) in Cotonou, either very high bandwidth radios such as the Ubiquity AirFiber [11] or fiber cables could have been used. Fiber cables were preferred because, in the Cotonou area, the radio spectrum is heavily polluted and the risk of interferences was high. Besides, this would have been the only link using such equipment. This would have involved training the staff and buying spares just for this link etc. On the other hand, building a fiber solution involved much more manpower, but in the specific case of the FSS, there was a way for the fiber cables to run almost entirely on "friendly ground" from the closest BT exchange to the FSS: the Benin Armed Forces headquarters that also needed to be connected to BJNet and to BT. The two cables could be buried in the same tube in the same trench and digging the trench itself was exercise for soldiers. So, this fiber solution was preferred in these circumstances although AirFiber could also have been preferred for this kind of site depending on the local street topology, distance, availability of manpower etc.

For the small sites unreachable from a BT exchange using rooftop masts, such as Adjara, Toffo, Dangbo, Aplahoué, a set of unassembled 55 m high bolted angled steel bars guyed masts with a thick zinc coating was imported. Bolted in order to be easily transportable and assembled on site; angled steel bars rather than hollow tubes to ease quality control of the zinc plating on all sides. Some telecommunication towers and guyed masts of the same source are in use in Benin for over 40 years, with very little maintenance, and they are still fine.

For the small sites needing several relays, towers located in BT exchanges that are not fed by fiber but by radio relays are used. Simply because all University Centers are close to towns that need communication (even if only plain old telephones), there is always such a way to reach them.

Unfortunately, there are many networks in need of reaching such places: banks, ISPs, mobile operators (although the largest have their own towers or guyed masts), and many of these networks were there before BJNet so that some of the communication towers of Bénin Télécoms are overloaded with radios and there is very little spare space to add more radios. Moreover, there are so many people climbing these towers that the risk of damage to radios is significant.

A typical case is Comè: one of the 55 m guyed masts had to be built on a site owned by the customs administration at a few hundreds of meters from the overloaded BT mast, with a short distance link from the top of he BJNet mast to half way up on the seaside leg of the BT mast, where nobody is interested. This BJNet mast is used as relay between the BT exchange in Comè, which is fed by fiber, and the town of Lokossa, where there is still no fiber. Currently, this link ends on a mast erected 9 years ago in IUT (Institut

Universitaire de Technologie) Lokossa. This mast was never used before by lack of a suitable relay in Comè, except for tests from the BT mast. This mast in IUT is corroded and the radio will be moved to the BT tower in Lokossa and the University institutions in Lokossa, such as IUT, will be connected using rooftop masts. Another radio link will go from the BT Tower in Lokossa to the 55 m BJNet guyed mast to be built in the new CU of Aplahoué.

Similar relay systems will be used from Dassa to Savalou, from Bohikon to Ketou, etc.

4.2 Workforce

It was decided to use as much as possible the workforce of partners (mostly UAC and UCL) and "friends" interested in the projects (the FAB). This workforce was provided free of charge to the project. In return, the project took care (on EU funds) of training these people in the suitable technologies and the means for their transportation and subsistence when working away from their usual workplace.

The workforce was trained in optical fiber soldering (use of fiber soldering machine) and measuring (use of reflectometer), in FO cable termination in patch panels and jointing cables in the field by a Beninese officer, Capt Dossou who holds a PhD in fiberoptics and also teaches in EPAC (Ecole Polytechnique d'Abomey Calavi), the engineering school of UAC).

Two members of the team were trained to become themselves trainers in the setting up of Mikrotik devices (now, UAC is even a Mikrotik academy). They trained the others.

One of the FAB officers did his Master thesis in the Belgian Royal Military Academy (RMA) on microwave links modeling under the supervision of Major Gilles and prof. Lobelle. A group of Beninese Signal Corps and Engineering NCO and soldiers were trained to assemble and build the guyed masts as well as setting up radio links from their top.

The FAB officers and UAC ICT engineers were trained in network design and they themselves designed the campus networks of UAC-Calavi and Camp Guézo in Cotonou.

Most of the training costs were borne by EU funding or contributed without charge by members of the UCL, Belnet, the UAC, the RMA and the FAB. The training activities were performed during the two years of the European funding of the project.

An advantage of using staff of the partners as workforce for the project was that they were still available after the end of the European funding of the project and thus could proceed with the building of the network long after this end.

An inconvenience of using the staff of the partners is that they also have other activities. Organizing the missions to set up network nodes in BT exchanges or radio links from the towers above was a hard job because it requires simultaneously people from BT, the FAB and UAC and getting them available at the same time is not obvious.

The logistics of building the project were mainly borne by the EU funds as well. Two cars were bought for transportation purposes (two because, to set up a communication link, it is better to have people at both ends) as well as enough fuel vouchers to finish the complete set-up of the network. A call for tender was issued to feed the staff when they were in the field building the network.

However, delays in setting up the network made it necessary for the partners to also contribute to these logistic costs. And to train more staff members to build guyed masts (some of the military members of the staff had been sent on mission abroad).

5 Synergy with the RERBénin Project

Funded by the World Bank, the West And Central african Research and Education Network (WACREN), the Africa Universities Association (AUA), a Beninese NREN initiative, called RERBénin, was launched in July 2013 and aims to establish a national network dedicated to education and research. Said network aims to take into account research centers and public and private universities in Benin. The objectives of RERBénin are part of the objectives of BJNet. Moreover, BJNet has already established some interconnections between university centers. Thus for better efficiency and convergence of efforts in achieving the interconnection of academic centers, it is suggested to set up a virtual network for RERBénin over the BJNet infrastructure, using the MPLS protocol (Multi Protocol Label Switching). This way to carry several types of traffic, such as academic traffic, over BJNet had already been planned since the early phases of the design of the network.

RERBénin will then take care of the administrative management and applications over this virtual network that only connects universities and research centers. However, BJNet and RERBénin have to agree on an economic model and on the way RERBénin would be involved in the development and extension phases of BJNet.

6 Political Issues

The political context was excellent for BJNet because Benin had a clear objective to become the "quartier numérique de l'Afrique", as stated in the "Document de Politique et de Stratégie du secteur des Télécommunications, des TIC et de la Poste" [10]. The project was consistent with the "e-Gouvernement" project of the State of Benin [1].

Building a NREN requires good cooperation with political bodies that will have to finance the running costs of the network after its construction (ministry of Higher Education and Research and ministry of Telecommunications).

Building a NREN using existing available and unused hardware resources belonging to the State (optical fibers in inter-city cables and space on communication towers) requires an excellent cooperation with the ministry owning these resources (ministry of Telecommunications).

There are two kinds of obstacles to good cooperation with ministries.

1. Some ministers are frequently replaced and so is their staff and they know it. They are thus often focused on a few short term issues. But more important, each time the minister and its staff changes, contact must be re-established with the new people and one must re-brief them thoroughly on the project, taking into account that, when a minister and his staff leave, their files are often not properly transferred to their successors.

The new staff is usually very busy organizing itself and focusing on its top issues, thus time is lost.

2. While, in universities, projects originate from outside (calls for proposals by subsidizing organizations) or take a bottom up course (proposals by professors), in administrations, projects are organized following a top down in several steps (i) the president/minister/staff has an idea or consultants are asked to come up with ideas; (ii)funding is found for a feasibility study by more consultants who come up with technical specifications; (iii) funding is found to build the project or part of it according to the technical specification.

These budgets often include not only the direct cost of the project but also indirect costs such as the salaries or salary complements of the civil servants supervising the project.

BJNet absolutely did not follow this scheme. It originated from university professors; funding did not pass through administrations and all expenses were strictly controlled by university accountants in Belgium, according to EU and Belgian public markets rules.

When the project was originally proposed in 2008, the first reaction of some administration (fortunately, not all of them) was therefore more or less "Hu, only a million euro, ok, transfer it to us and it will help us finance part of the feasibility study". In other words, while some civil servants, particularly those with a fixed salary, (and the military authorities) saw clearly the advantage of the project and all the other future projects that it was enabling, other ones were reluctant to get involved because the indirect costs in the administration were not included and the organization of the project did not match their usual practice. Consequently they spread the opinion that the project was shady and it was safer not to be involved.

The above obstacles caused a lot of delay in the project and so did the presidential election of 2011 (all ministries and administrations were almost blind to anything else for a period of about six months).

However some ministers (e.g. D. Adadja), Directors of Cabinet in some ministries (e.g. W. Martin) and staff members at the presidency very quickly understood the benefits of the project for their country and actively supported the project even after they had been replaced in their former functions. They managed to get the needed endorsement of the project by the council of ministers [6].

Another political issue that interfered with the project was the possible privatization of the State owned Bénin Télécoms company, which owned the inter-city optical fiber cables and communication towers we planned to use. This uncertainty accentuated by the fact that decision makers in the company were replaced several times in the course of the project also caused delays.

On the other hand, many employees of Bénin Télécoms very well understood the advantage of the project for the country and for the company too, in particular, the innovating technologies used by the project and that could also benefit the company.

All this caused long delays but the project was never blocked and could always proceed, although slower than expected. These delays induced unexpected costs and, in September 2014, the project coordinators decided to return to the partners and

1. explain to them that an extra funding of about 5 % of the original EU funding was necessary because of the delays and the indirect costs in the ministries;
2. explain the urgent need to create and plan a budget for a permanent structure to operate the network.

Both requests have now been taken into account.

7 Conclusions

The BJNet project shows that all developing countries can build a NREN by using existing and available local resources, both material and human, with a limited amount of additional funding.

Originally, BJNet had not been planned to use this approach, but because of the big changes on the higher education landscape in Benin, this approach was more reasonable. Since the timeframe of the availability of EU funding for the project was short (2years), the BJNet team had to take the design decisions before convincing the authorities that it was the right thing to do. Now that the feasibility of the approach has been shown, other countries can follow it, but the different steps should preferably be performed in the following order.

1. Using the BJNet example, convince the highest possible authorities in the country of the adequacy of the approach.
2. Obtain the authorization to use available and unused passive telecommunication infrastructure: dark fibers in existing cables and antenna locations on communication towers. Such passive infrastructures are often available because activating them (i.e. installing the needed electronic equipment for the classical services) is expensive. Thus, in many instances cables with tens of fibers are installed (the total cost of buying and installing an optical fiber cable does not much depend on the number of fibers), but only a few fibers are actually used. Many telecommunication towers were built some years ago and except in vey densely populated areas, there is often plenty of available room for antennas on these towers.
3. Convince the future beneficiaries (e.g. universities) of the network to provide (at their own cost) the manpower to build it, even if they do not have trained staff (they usually have engineers that can esily be trained on the technologies to be used).
4. Evaluate the needed additional funding, i.e. the cost of the equipment to be purchased and the cost of the logistics for building the network: vehicle cost (borrowing, buying or renting plus maintenance costs and fuel costs), per diems of the staff when it is in the field, international travel, cost of tasks that have to be ousourced, training cost, etc.
5. Find a funding to cover this cost and start building the network keeping all the time the authorities and the beneficiaries informed of the progress.

And during all these steps, let the project be steered by a team of dynamic and committed people understanding all its technical and managerial aspects.

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References

1. Ayoyo, C.: Etude de faisabilité du e-Gouvernement: Rapport Final, NLC Groupe, (Sept 2008), Cotonou, pp. 42–46 (2008)
2. Belnet: Belnet History (2014). https://www.belnet.be/en/about-us/history
3. Belnet: Belnet publications (2014). https://www.belnet.be/en/about-us/publications
4. Ciena: JANET Delivers Europe's First 40 Gbps Wavelength Service across National Research and Education Network with Ciena (2007). Ciena press release on www.ciena.com
5. Cormier, D., Siemens, G.: Through the open door: open courses as research, learning, and engagement. Educause Rev. **45**(4), 30–39 (2010)
6. Dossoumou E. : Communication gouvernementale 1298/12: relevé02 des décisions prises par le conseil des Ministres en sa séance du mercredi 30 Janvier 2013. Secrétariat du Gouvernement, Cotonou (2013)
7. ITU: Propagation by diffraction, ITU, recommendation ITU-R P.526–8 (1978)
8. Masters, K: A brief guide to understanding MOOCS. Internet J. Med. Educ. 1(2) (2011). doi: 10.5580/1f21, http://ispub.com/IJME/1/2/10995
9. Nowlan, M., Fosters, D., Reijs, V.,Rotkop, A., Wierenga, K., Witzig, C.: The Future Roles of NRENs, Aspire, September 2012. https://www.terena.org/activities/aspire/docs/ASPIRE-future-of-nrens.pdf
10. Présidence de la République du Bénin, 2011, Document de Politique et de Stratégie du secteur des Télécommunications, des Tics et de la Poste, April 2011
11. Ubiquity: Airfiber5. https://www.ubnt.com/airfiber/airfiber5/