

Inverse Infrastructures in Rural Areas in Developing Countries

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R. Westerveld, February 2014

Overview of Presentation

- The rural telecommunications setting
- Technical rural network development
 - Problem solved ?
- The explosive emergence of Mobile (cellular) networks
 - Do they really serve the rural areas ?
- Limits to top-down approach.
- Three examples of Inverse Infrastructures
 - OpenBTS
 - Daknet
 - Village Telco
- Discussion

Press clipping

Cape Town, ITWeb, 18 February 2009

“The Independent Communications Authority of SA (ICASA) has been accused of heavy-handed tactics. This follows its inspectors “confiscating” equipment belonging to Dabba, at Orange Farm, an informal settlement 45km from Johannesburg.

Dabba is an emerging telecommunications operator that has the support of the Shuttleworth Foundation and US equipment maker Cisco.

It is rolling out a village telecoms model that will encourage low-cost connectivity, while building entrepreneurs in some of the country's poorest areas.....”

No academic discourse

- Writing about self-organized, user-driven, decentralized infrastructure developments also called 'Inverse Infrastructures' (Egyedi et.al 2007) in Rural Africa is not a pure academic discourse.
- The news items, cited before, show the real live conflict between an incumbent operator and a bottom-up telecom initiative.
- Apparently these initiatives are really getting off the ground and start to hurt the established interests of incumbents.

Rural characteristics

- scarcity or absence of public facilities
- scarcity of technical personnel
- difficult terrain
- severe climatic conditions
- low level of economic activity
- low per capita income
- underdeveloped social infrastructure
- low population density
- very high calling rates per telephone line
- destructive influence man and animals



Source: Final report of ITU-D Focus Group 7

Why do we need rural comms ?

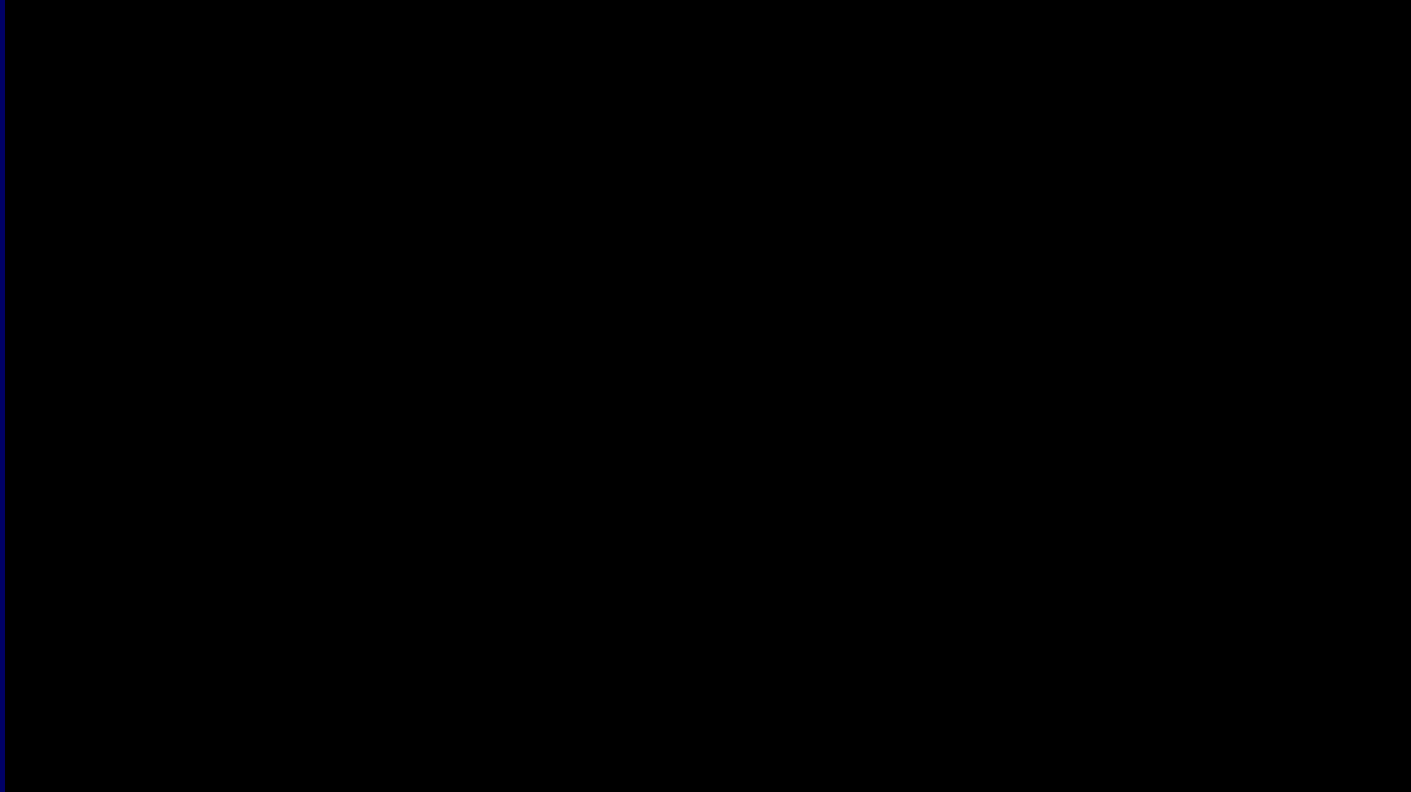
- 'Universal' service obligation
- Multiplying socio-economic effect
- Stop migration to cities
- Rural users needs



UN Millennium Development goals

- The United Nations have established in 2000 the Millennium Development Goals (MDG). One of the targets is 'In cooperation with the private sector, make available the benefits of new technologies, especially information and communications technologies'
- However: 'Internet use is increasing rapidly, but the poorest regions lag behind.' (UN 2008). By the end of 2006, 1 billion people were connected to the Internet – just over 18 per cent of the world's population. But the digital divide is still wide'.

What can communication mean?



Source: Nokia Siemens, The Village Connection

Last mile

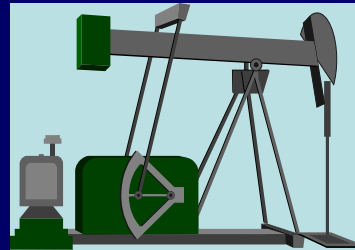
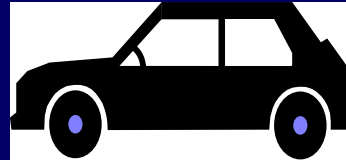
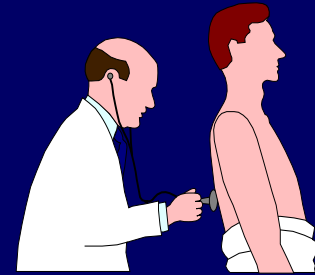
- The last mile is defined in a developed region telecommunications context as the physical connection between a subscriber and the nearest telephone exchange
- most often *wired*, e.g. copper, coaxial (cable), fibre, or powerline; and also *wireless* through mobile cellular networks with acronyms like 2G, GPRS, UMTS, 3G, HSDPA, 4G and LTE
- Last mile connectivity can also come through fixed wireless networks like WiFi, WiMAX, and satellite
- It is the last bit of connectivity between a service provider and an end user (subscriber)

Design considerations

- The *last mile problem* is not limited to telecoms
- similar challenges apply to water supply, health, electricity, transport etc.
- For an operator the challenge is to design a distribution network where the part of the network that is **shared among many users** is as large as possible.
- In that way the costs can be distributed over many users
- The access points of the shared network are planned as near as possible to a cluster of users, so that the 'last mile' line is shortest.
- Last mile sometimes called 'local loop' or access network

Rural users

- Government
 - Services, Police, Fire brigade etc.
- Health care
- Transport
- Agriculture
- Education
- Industry
- Tourism



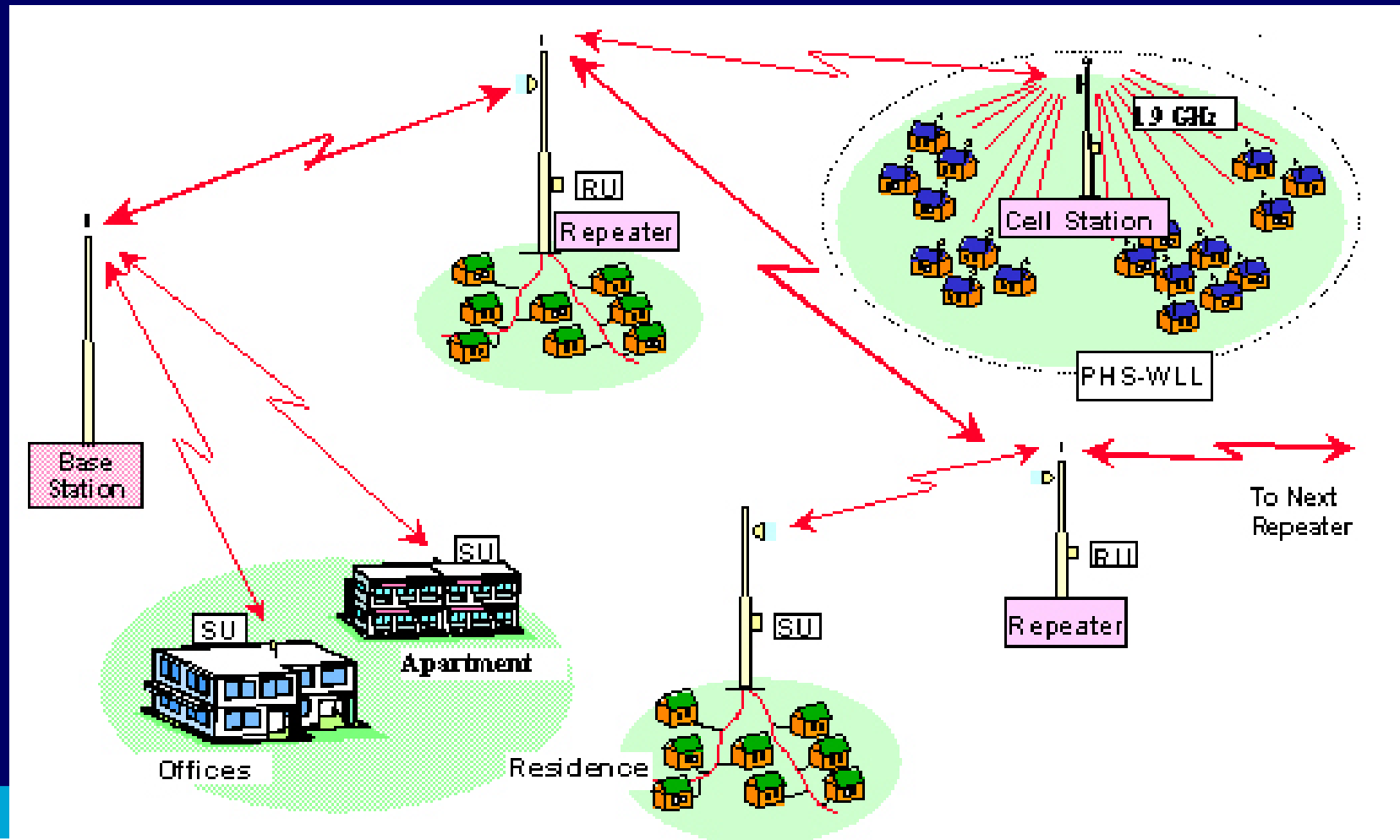
The Cost problem

- Extensive wide area transmission system to be shared and paid by relatively small number of subscribers
- Per line cost can be 5 to 10 times more as compared to urban areas
- Revenue/cost ratio
- Different kinds of revenue
 - outgoing, incoming
 - Payphone, Business and Residence

Technical solutions with Radio Network

- Point-to-MultiPoint/wireless local loop systems
 - DECT
 - WiMax
- Satellite
 - Intelsat (GEO)
 - Iridium (LEO)
 - VSAT (GEO)
- Mobile Cellular networks
 - GSM etc.

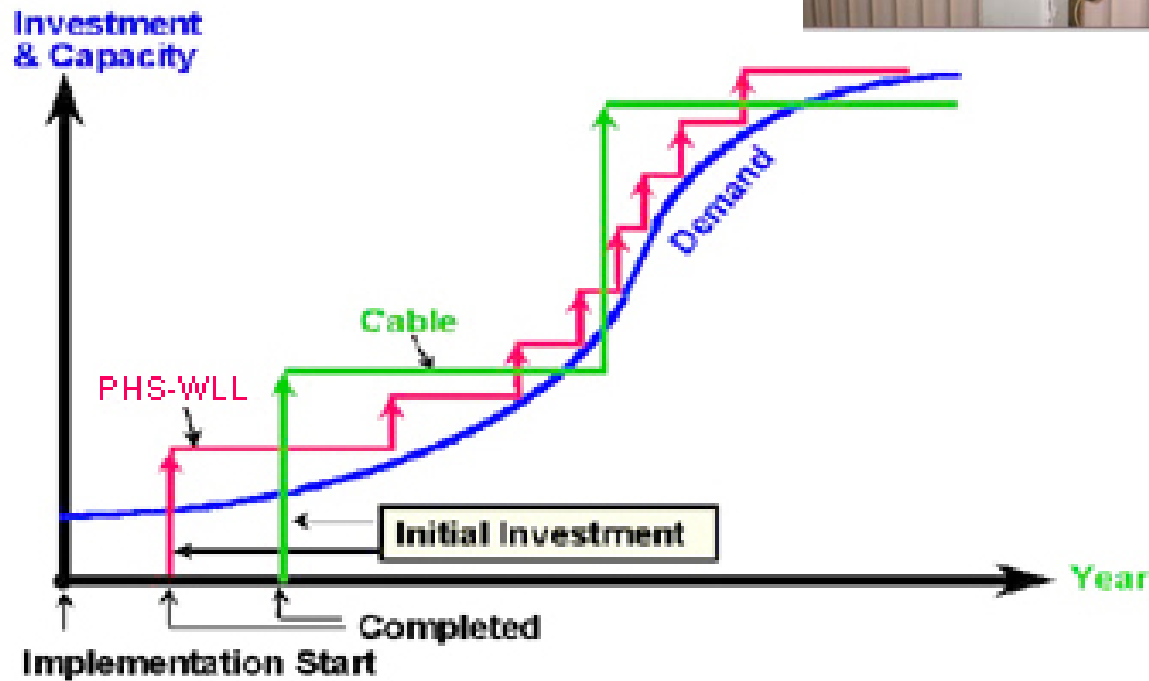
Radio Network solutions, Point-to-MultiPoint/wireless local loop systems



Comparison Wireless-Wireline



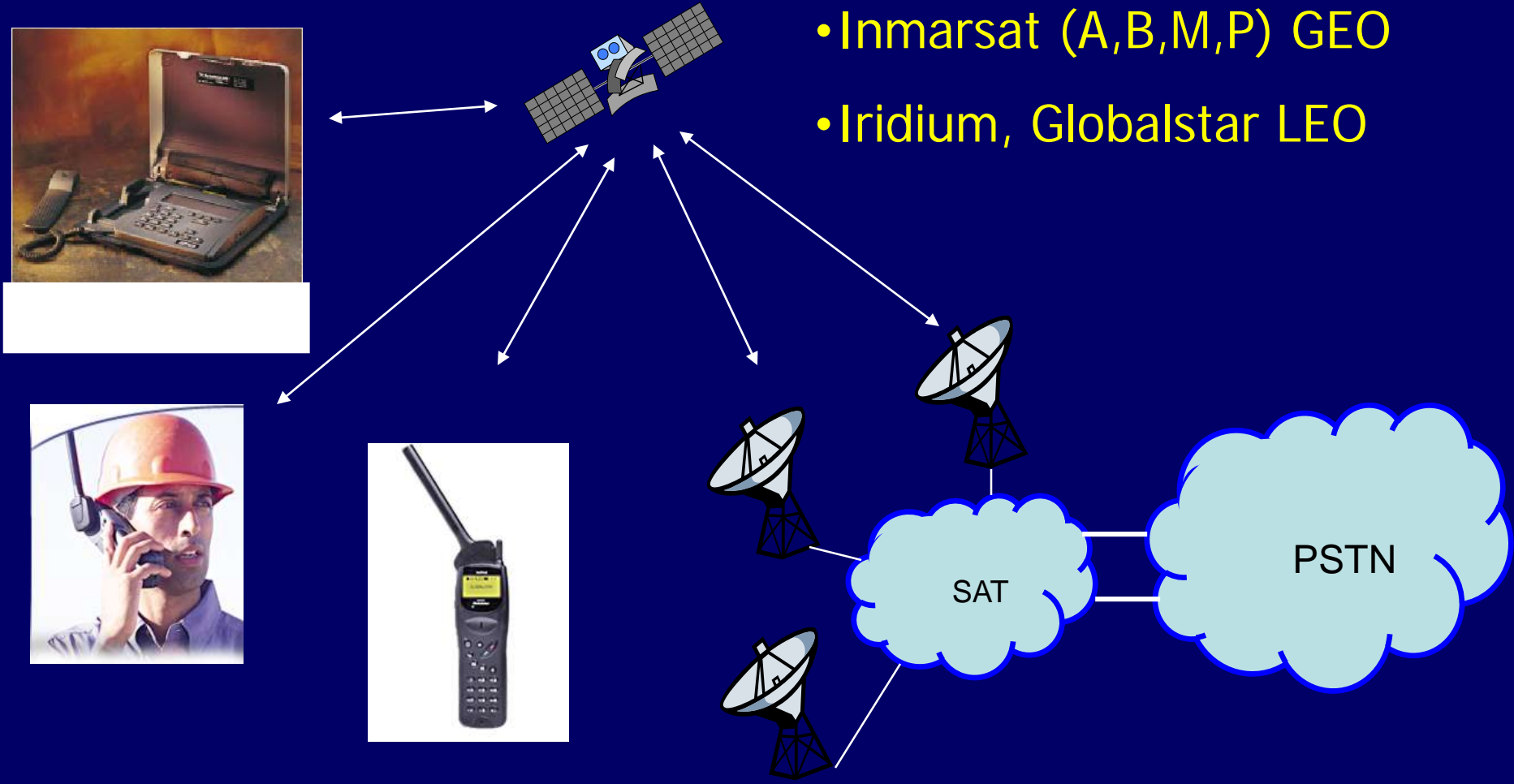
DECT solar powered subscriber Installation



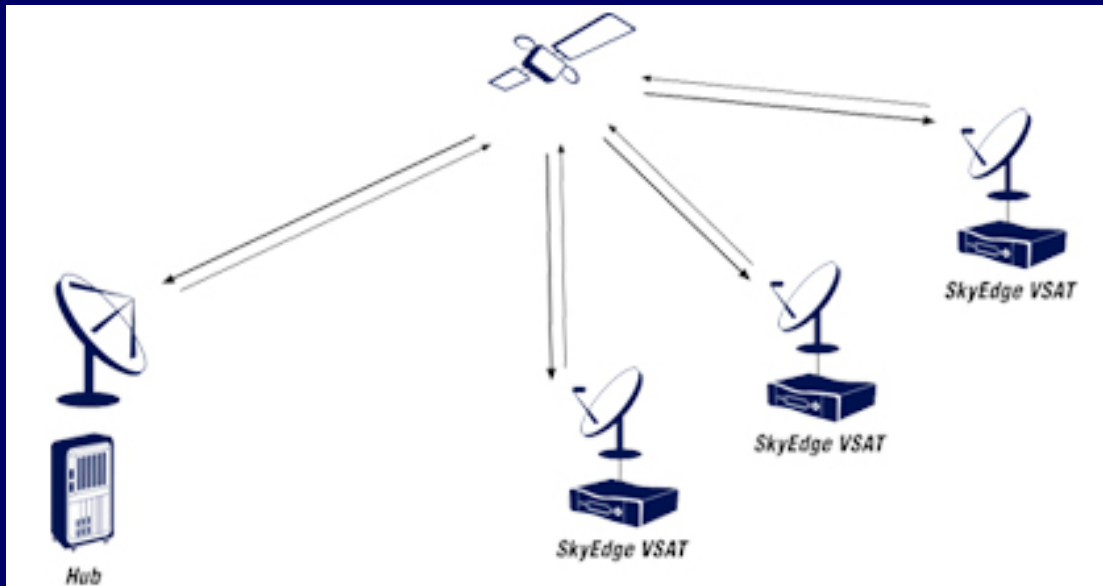
Source: Telkom SA

Radio Network solutions, Satellite 1

- Inmarsat (A,B,M,P) GEO
- Iridium, Globalstar LEO



Radio Network solutions, Satellite 2 VSAT



- ~ € 40, per 1 Gigabyte, p.m.
- 512 kb down, 256 kb up



Why did it not work out?

- Lack of Capital
- Access to (foreign) technology
- Organisation and Management
- Skills
- Operation and Maintenance of large networks
- Socio-economic causes
 - States with high ethnic diversity
 - Weak central government
 - Corruption

Can technology alone solve the problem ?

- **"What is the most important barrier to the provision of access to all Africans?"**
- ITU Telecom Africa 2001 Policy Development Forum participants ranked four possible reasons as follows:
- Lack of funding (47%),
- Regulation (23%),
- Lack of public and private sector co-operation (18%)
- and only as a last item Inadequate Technology (12%).

From SA experience with WLL DECT 1

- At the time of design WLL DECT was a viable technology
- However there was little take up by manufacturers of equipment, so a few suppliers remained.
- Because of lack of competition cost per line at the customers premises of this system remained high.
- Cost of other systems like CDMA and GSM went down,
 - world wide adoption, competition and expansion

From SA experience with WLL DECT 2

- The deployment of the system required accurate planning and needed unavailable coordinates of the customers
- Delays, that Telkom encountered, were attributed to:
 - Poor planning on the part of the operator.
 - E.g. they did not anticipate the amount of time necessary to negotiate rights of way agreements
- At the end DECT was a technical success, commercially however it was a failure.

From SA experience with WLL DECT 3

- Too expensive for the rural areas where the poorest people of South Africa lived
- Telkom's post-paid tariffs were not affordable for the poor. Telkom had to dismantle hundreds of thousands of these subscribers due to non-payment.
- As local ownership is missing, one can attribute the lack of care for installed systems by the rural users, to this issue.
- Shareholders limited interest in rural service provisioning

Then Mobile (cellular) networks arrived

- With the right foreign and local investments operators can make big profits while 'contributing' to development
- Surprisingly rendering a mobile Average Return Per User (ARPU) of aprox. US\$ 10 per month in African countries where people don't earn much more than US\$ 30 per month?! (Celtel Kenya).



Mobile (cellular) networks 1

- Subscriber growth in Africa - more than 50 % per year - is the highest in the world
- Rapid deployment even in some rural areas
- Prepaid cards
- Cheaper than wireline
 - Cellular investment/subscr. US\$300-400
 - Wireline US\$1000/subscr.
- But still expensive
- Join which world??



Mobile (cellular) networks 2

- Around the world, mobile users have pioneered new, unintended uses for their phones. From “beeping” to credit-transfer.
- Poor communities, given the opportunity, will adapt technologies to better serve their needs
 - E.g. “Crowdsourcing”
- What were the critical success factors that made the fast introduction of mobile cellular technology possible?
 - Celtel Dr. Mo. Ibrahim



gg58394321 www.gograph.com

Mobile (cellular) networks 3

Needed Investments

Investors challenges

- Unstable political environments
- Unpredictable economic performance
- HIV/Aids
- Corruption
- Penal taxation and regulation
- Outdated technology

What do investors want

- Stable political environment
- Predictable economic performance
- Educated workforce
- Transparency and Rule of law
- Sensible tax and regulatory regimes
- Modern technology

Source: Dr Mo Ibrahim, Celtel

Mobile (cellular) networks 4

Why did Celtel succeed?

Celtel focuses on managing the risks

- Ethics and values
- Portfolio
- Governance and transparency
- Understand capital markets
- Develop local people, build local businesses
- Corporate social responsibility

Source: Dr Mo Ibrahim, Celtel

Charge your Mobile Phone

- It costs 500 Ugandan Shillings (0.2 Euro) to have a battery recharged similar to the price of 2/3 phone calls.



A number of barriers to use:

- customers cannot use their phone whilst the battery is being charged;
- the customer risks that their battery being swapped for an inferior one; a perceived risk of phone theft



Not one phone, but many!

Own observations in Ghana (Dec. 2009)

- 'Everybody', even in suburban areas, has a phone
- Get your house painted FREE by a mobile operator
 - In his colors and logo
- Carry more than one phone, one for every operator!
 - High interconnection tariffs
 - Call your friend with mobile phone of his own operator
 - Lower call charges

Some other drawbacks of mobiles

- Most of the money that low income people are spending on mobile communications is leaving the community (and even the country) and is not used for local development (Song 2009)
- As profits of operators are so high it means, that users could pay a lot less for the mobile services and still render a reasonable profit for the operator
- Mobiles might represent one more step in the ingestion of the poor by the consumer society.
 - They are sacrificing food for (potentially economically-valueless) status and an identity of modernity, youth, urbanicity, etc that they believe mobile ownership brings (Heeks, 2008).

Limited coverage in rural areas

- Although mobile networks are expanding rapidly there are still regions in developing countries that will stay underserved for the reasons that have been mentioned before. (Singh, 2009)
- The cellular coverage remains mainly located in or near urban areas, while 56 % of the population still lives in rural areas (Vital Wave Consulting 2008).



Rural communities still lacking connectivity in Africa

November 8, 2010, written by James Middleton, Informa Study

The mobile revolution has failed to touch all parts of Africa, and lack of connectivity among rural communities is holding the continent back from becoming a member of the global knowledge economy.

- SIM penetration still remains under 20 % in a few parts of the continent,
- But even in markets > the 50 % mark, the level of penetration in most rural areas is below 10 per cent,
- This represents something of a problem when two thirds of the continent's population resides in rural Africa.

More from Informa study

- *Access to power* was a recurrent theme of the survey as a barrier to greater rural connectivity.
 - ahead of cost of ownership and lack of awareness
- Over a quarter of respondents answered that the *provision of cheaper devices* represented the best opportunity for the vendor community, just ahead of network expansion (21 per cent) and use of alternative energy sources (20 per cent).

Can bottom-up do better?

- Top-down systems were deployed with mixed success
 - WLL DECT and Mobile
- Some emerging bottom-up systems, might provide better opportunities for affordable and sustainable telecommunications in rural areas in developing countries.
- And, because they are “invented and developed” together with local people, they might serve them better for what they really need.

Some examples 1

- The “First Mile First Inch” organisation (FMFI, 2009) tries: ‘to achieve social and sustainable technical innovation that is scalable and replicable
 - Broad band/IP based, Low cost, affordable
 - Access = 1st mile, Application = 1st inch
- This will enhance social interaction and networks of people
- Wireless technologies and open source telephony applications have developed enormously and can support this approach.

Some examples of many initiatives

- Telecentre experiments, providing telephony, fax, internet access and computer training in rural villages
- Open BTS, replacement of the conventional 2G/3G network's with a more modern SIP network, but without any changes to the handsets
- WiFi access networks and so called Village Telcos that also use WiFi and Voice over IP and meshed networks.
- Adhoc networks (DakNet, Ratanakiri Internet Village Motoman), to show a different approach to access to internet using wireless technology with an asynchronous access (not always on-line) mode.

Different type of services offered

- On one side the offering of, first of all, basic telephony services (e.g. OpenBTS and Village Telco).
- On the other side projects are started with “broadband” internet access as a primary goal (e.g. DakNet) in mind.
 - However they only offer asynchronous access at certain times of the day.
 - Intermittent communication networks
 - Data mule (e.g. bus, motorcycles)
 - Non-traditional (also non-obvious) means of communication

Local appropriation of ICTs

- It concerns communities and groups selecting and adopting communication tools according to their own different information and communication needs identified by themselves.
- They then can adapt the technologies so that they become rooted in their own social, economic and cultural processes. (Michiels 2001)

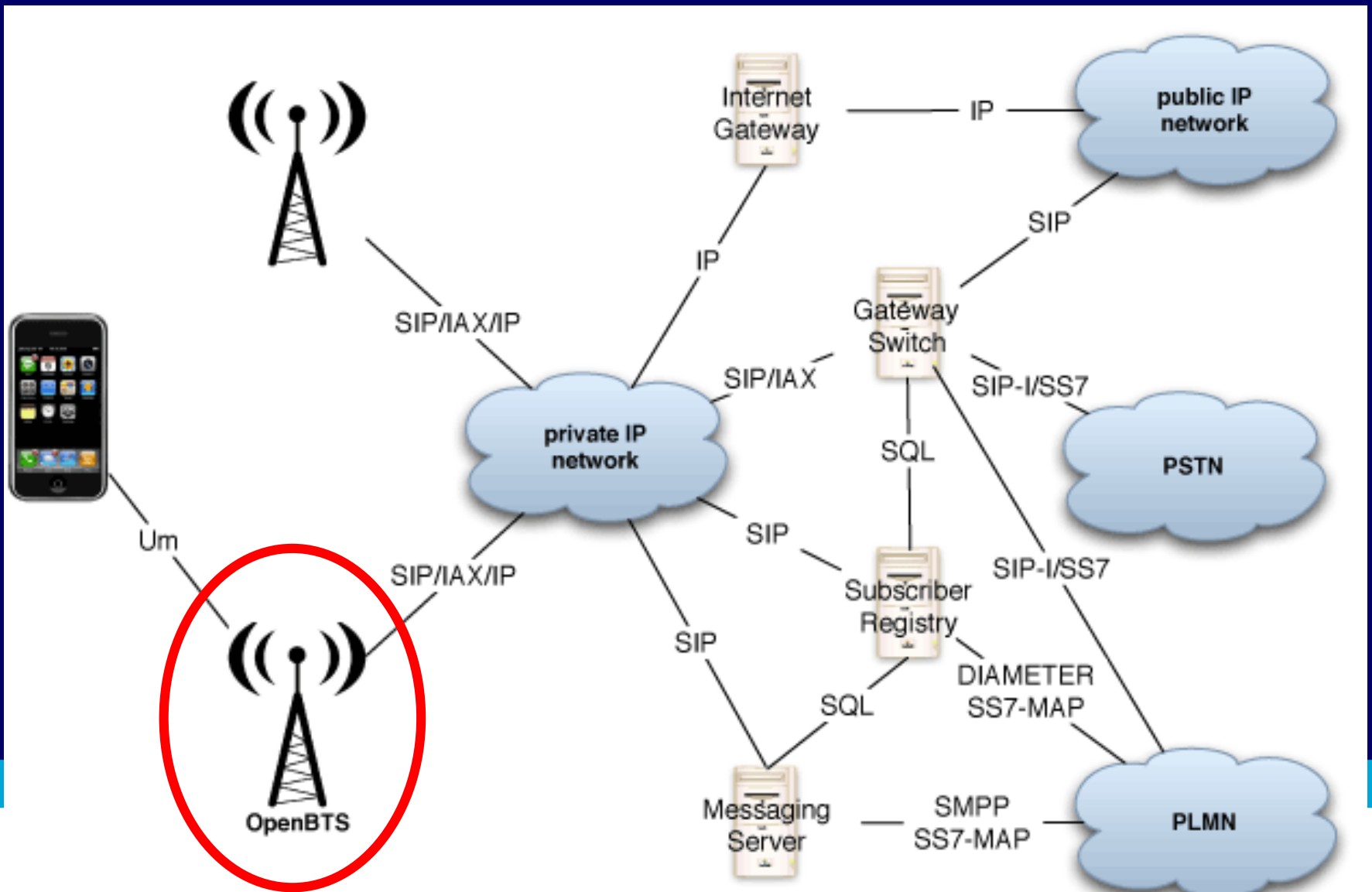
OpenBTS



- The defining feature of the OpenBTS system is the replacement the conventional 2G/3G network's SS7-MAP structure and all of its various components (MSCs, BSCs, TRAU, SGSNs, etc.) with a more modern SIP network (VoIP), but without any changes to the handsets.
- The key ingredient that makes this change possible is OpenBTS, a software defined radio implementation of the GSM radio access network that presents normal GSM handsets as virtual SIP endpoints. Source: www.rangenetworks.com

OpenBTS architecture

Source: www.rangenetworks.com



This OpenBTS approach offers the following advantages:

- much lower deployment costs (CAPEX), especially for small operators
- much lower operating costs (OPEX), for carriers of all sizes
- plug-in compatibility with existing SIP-based core networks and with future IMS core networks
- Some Challenges:
 - Power supply (large part of total deployment cost)
 - Regulatory issues
 - Numbering plans

Source: www.rangenetworks.com

DakNet 1

- Traditional focus on standard telephone service, why not go for broadband wireless internet connectivity?
- Establish a kernel of a user network that will grow seamlessly as the village's economics develop?
- DakNet is an adhoc network that uses wireless technology to provide *asynchronous* digital connectivity
- Developed by MIT Media Lab and successfully deployed in both India and Cambodia
- Cost two orders of magnitude less than that of landline solutions

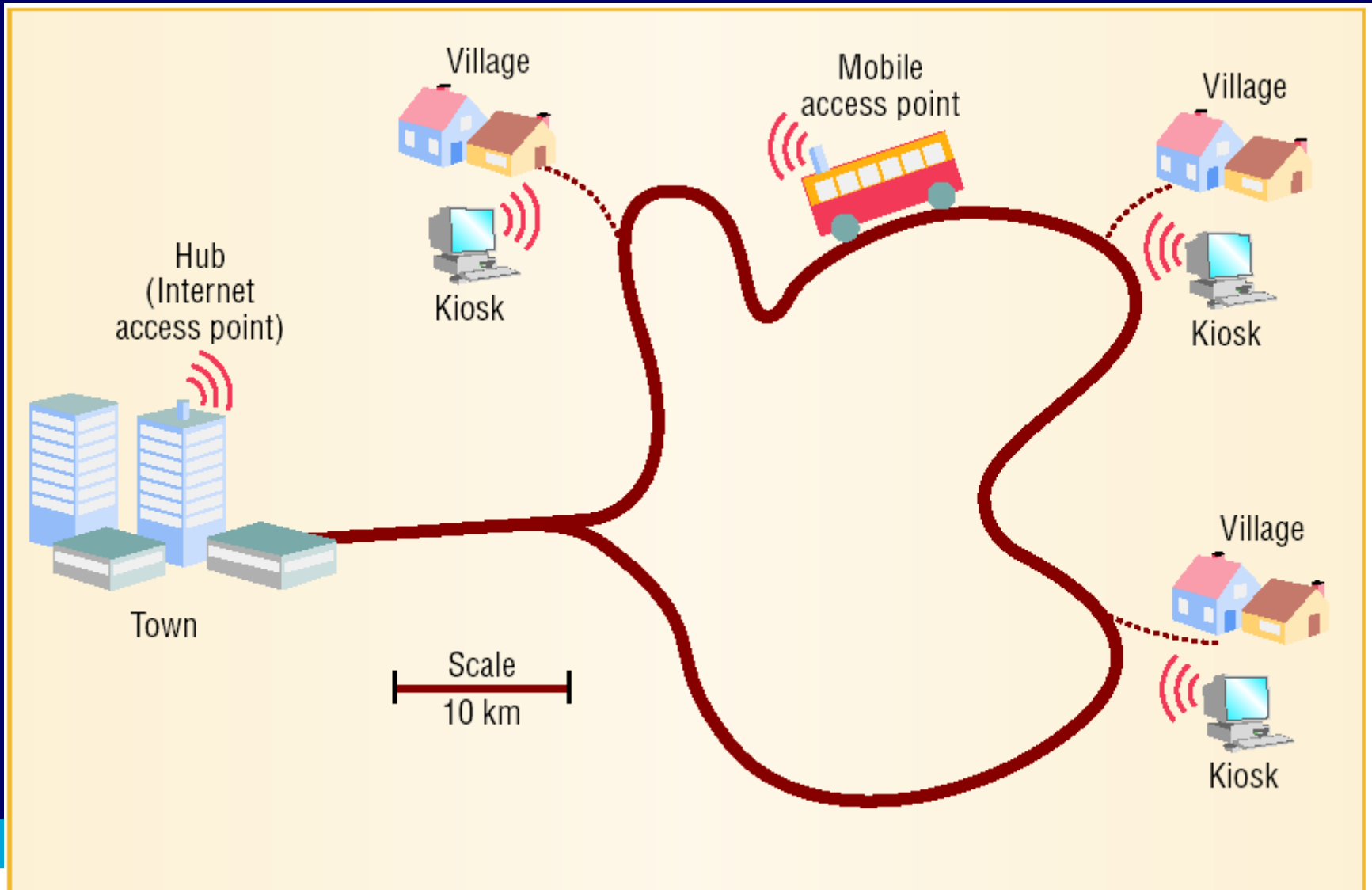
Source: A. Pentland, MIT Media

DakNet 2

- Mobile Ad Hoc Connectivity
- 'Drive-By Wi-Fi'
- Starting point for rural connectivity projects.
- DakNet concepts.
 - Physical transport, in this case a public bus, carries a mobile access point (MAP) between village kiosks and a hub with Internet access.
 - Data automatically uploads and downloads when the bus is in range of a kiosk or the hub.
- Services provided
 - E-mail, Off-line web browsing, Voice mail, E-shop



DakNet 3



DakNet economics

by Amir Alexander Hasson, founder 'United Villages'

- In rural areas, it's not economical to provide cellular coverage and traditional forms of telecom infrastructure.
 - Move further out from cities and towns, the population density and income per capita keeps dropping.
 - So, dollars or Indian rupees per square kilometer go downward very quickly. And, at the same time, the cost of connectivity per kilometer increases geometrically.

Source: A.A. Hasson, United Villages

DakNet economics cont.

by Amir Alexander Hasson, founder 'United Villages'

- If you can get the infrastructure costs low enough, then you can actually turn a profit at very low rates of adoption, and very low ARPUs (average revenue per user).
- Digital divide, "Last-mile problem", "First-mile problem"

Source: A.A. Hasson, United Villages

DakNet prepaid cards

- Critical success factor
- Lines of credit are very poor in these parts of the world, and so the prepaid card tackles that problem.
- It enables vendors to deal with customers on a real-time transaction basis.
- In other words: you give me the money; I give you the card; you have stored value in your account which deducts over time.
- Proven also with mobile cellular networks



Source: A.A. Hasson, United Villages

Ratanaki Internet Village Motoman 1

First Mile solutions

- Access for 4 wheels vehicles is sometimes impossible
- So why not use only 2 wheels
- Motoman equipped with wireless access point



Ratanaki Internet Village Motoman 2

First Mile solutions



Ratanaki Internet Village Motoman 3



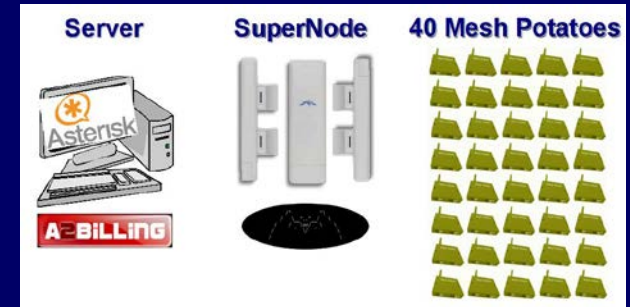
Welcome to 'Village Telco'! 1



- This is an initiative to assemble/develop the cheapest,
- easiest to setup,
- easiest to manage,
- scalable,
- Open Source,
- standards-based,
- wireless local do-it-yourself telephone company *toolkit* in the world.

Source: <http://villagetelco.org/>

Welcome to 'Village Telco'! 2



- The South African company Dabba with support from Internet Solutions is creating a business model that will allow micro-operators to function. Open software and hardware development support is coming from Shuttleworth Foundation.
- Village Telco startup system should cost less than USD5000
- Add low cost VOIP handsets or analogue telephones

Welcome to 'Village Telco'! 3

- A "village telco" would allow villages/communities/organisations to choose their own interconnections and upstream providers, to use VOIP where it is most cost-effective and mobile/POTS services.
- It would also allow "village telcos" to interconnect among themselves.
- There are also plenty of opportunities to provide upstream services to a "village telco", to interconnect, to offer value-added services, etc.



Source: <http://villagetelco.org/>

What makes the Village Telco different

- It is its focus on voices services,
 - both from the point of view of making them work as effectively as possible at as low a cost as possible
 - but also from the point of view of creating a sustainable business model for entrepreneurs.
- Access to telecommunications is least available and most expensive for the poor in developing countries

Source: <http://villagetelco.org/>

Access to telecommunications

- On the one hand, telecommunications operators in developing countries have focused their investment on markets that will provided a *high rate of return*.
 - Poor communities are *low down on the list* for the deployment of infrastructure.
- Equally, developing countries telecommunications markets are characterised by a lack of effective competition resulting in *high communications costs*.
 - This means that even when the poor are *technologically* included, they are often still *economically* excluded from making full effective use of telecommunications access. Source: <http://villagetelco.org/>



The mesh potato network 1

Server



SuperNode



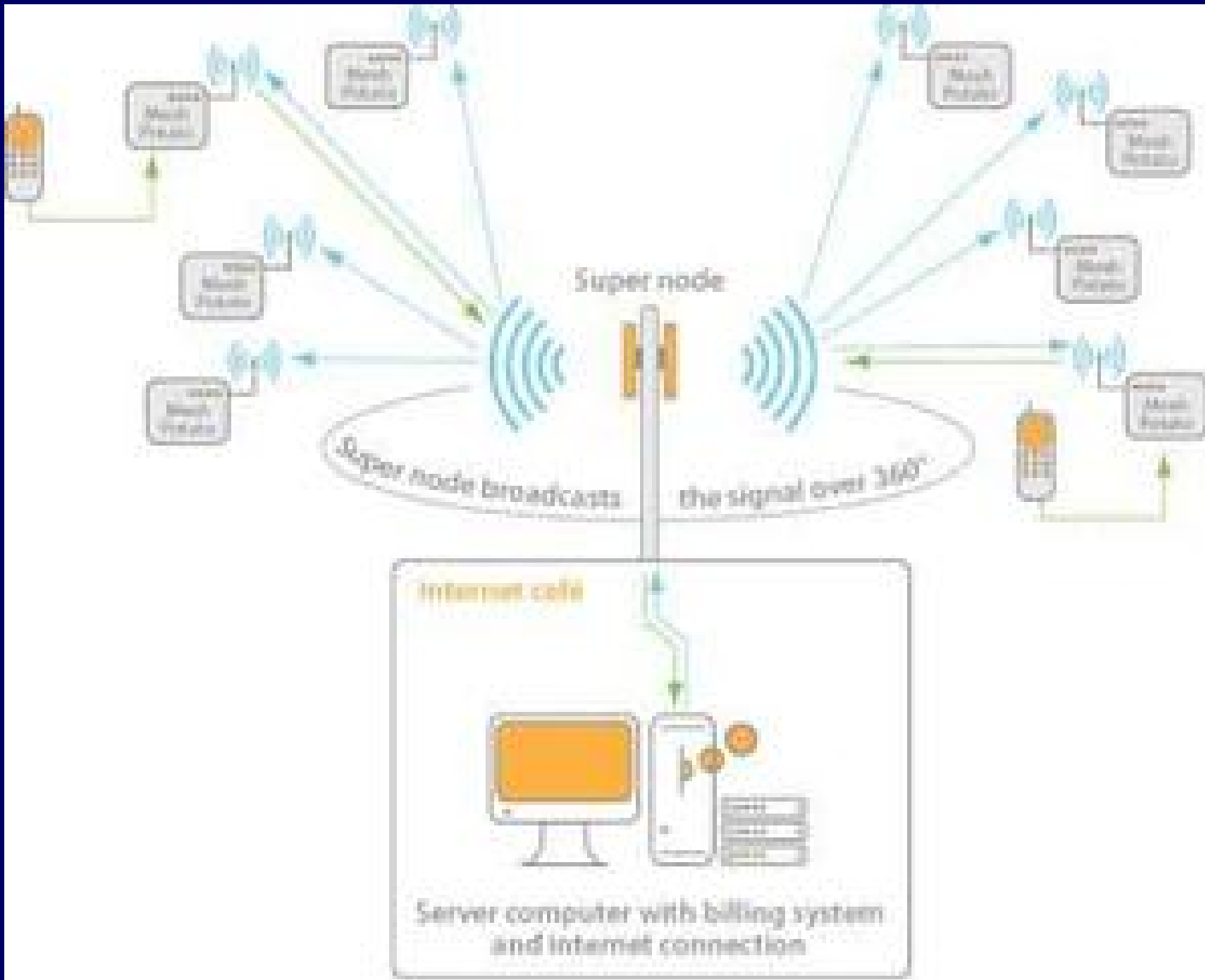
40 Mesh Potatoes



The mesh potato network 2

- The internet signal enters a computer server in the Village Telco office (perhaps an existing internet café) via a broadband cable connection or satellite link.
- The signal is then carried to an antenna on the roof of the Village Telco premises, or other high place.
- The signal is then transmitted by the 'super node'— three external access points placed around the antenna providing 360° coverage.





The mesh potato network 3

- The Mesh Potato, placed in the customer's office or home, picks up the signal, which is carried throughout the network from one Mesh Potato to another.
- The customer plugs a standard telephone into the Mesh Potato and makes a call.



The mesh potato network 4

- The Mesh Potato converts the telephone signal from analogue to digital and transmits it back to the super node, or to another Mesh Potato on the network, which will keep passing the signal on until it reaches the super node.
- The signal then reaches the antenna and arrives back at the server computer in the Village Telco, connecting the caller with the internet and other telephone networks

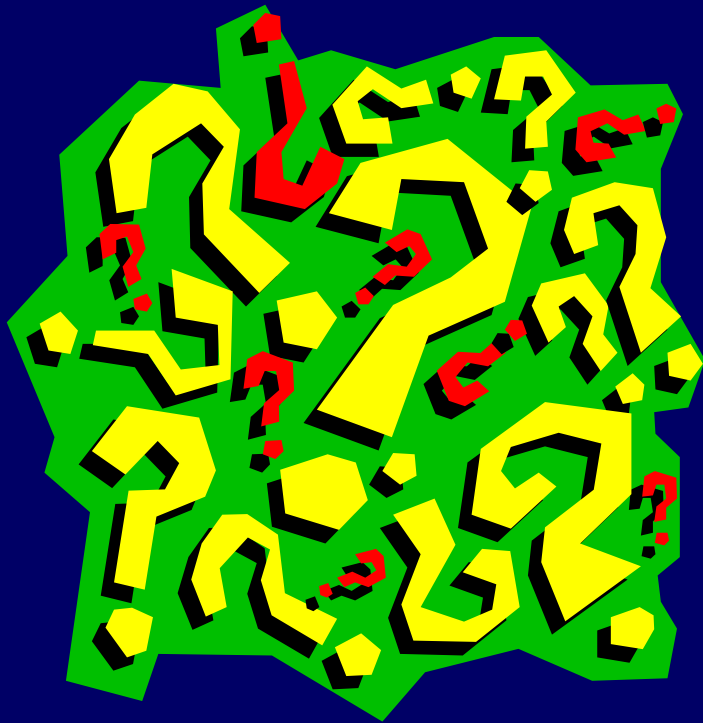
Discussion

- The top-down approaches mostly initiated by incumbent operators have not really tackled the problem.
- Emerging cellular mobile networks achieved an unexpected level of deployment
 - Opening of the different countries to mobile service competition. Also the influx of foreign capital played an important role.
- Still no wide rural coverage and it is relatively expensive

Bottom-up ?

- DakNet has a track record of several years and seems to be quite successful.
 - They also have to cope with local infrastructure and transportation system limitations. It provides an adequate solution for the short- and mid-term.
- Village Telco is still in its early stages of deployment and is in itself promising (However designed by geeks?).
 - Critical success factor is local entrepreneur that decides to invest in and run a Village Telco
 - Only with sufficient take off can equipment be mass produced and can the cost come down

Questions

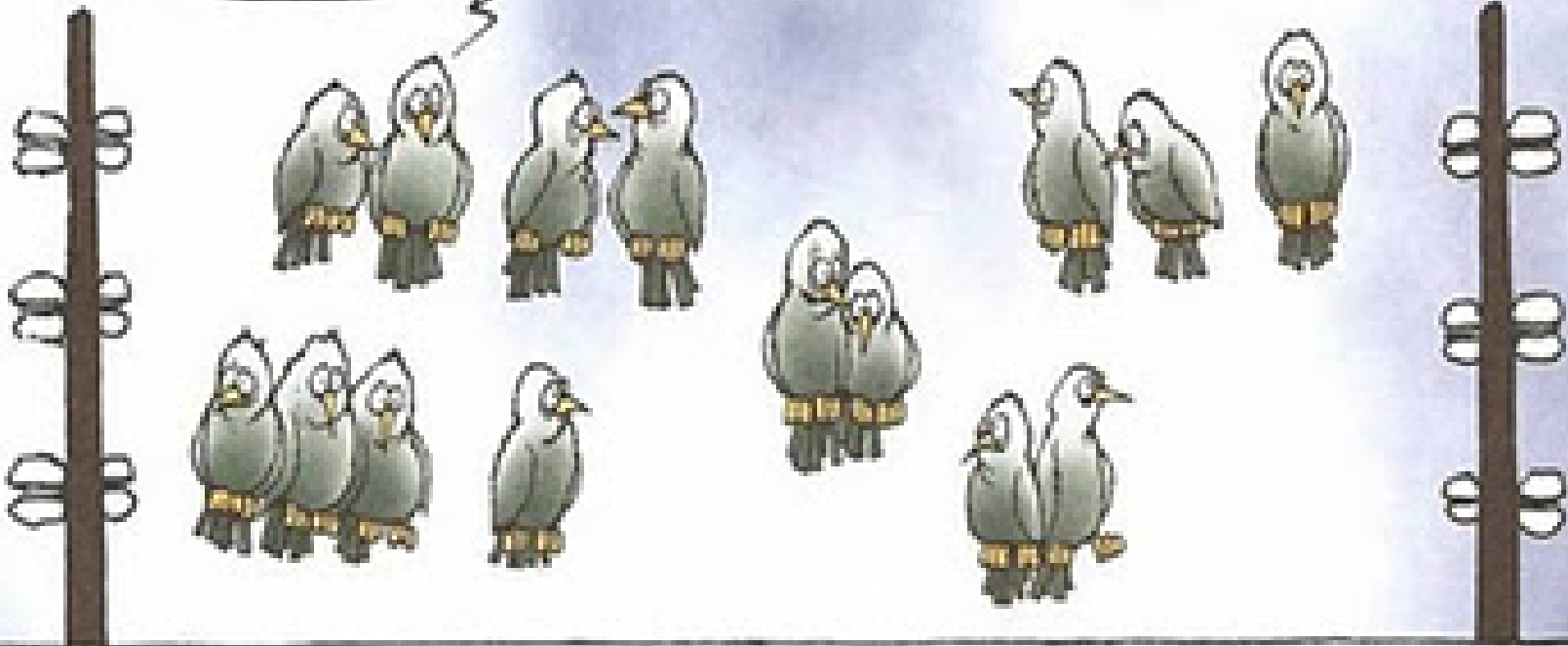


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It is a bit freaky with this wireless technology



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