Community driven IP Telephony

Technical Alternatives

Alberto Escudero-Pascual
aep@it46.se
IT+46
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Preamble

This technical report examines the possibility of building *wireless voice infrastructure* in a rural setup in a developing region. Inspired by the community wireless network model, where the local community is responsible of building and maintaining the communication infrastructure, we explore the possibility of deploying of *wireless community IP telephone networks*

The document aims to identify suitable technical solutions to provide low cost and scalable telephony networks.

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Disclaimer:
This technical report is an extension of the *VoIP4D primer: Building telephony infrastructure in developing regions* available at http://voip4d.it46.se Basic concepts of IP telephony are introduced in the primer and this document just focuses on VoIP wireless clients.

Alberto Escudero Pascual, IT +46

1 Introduction to VoIP components

The following section gives a sort description of each of the components that can be used in a WiFi IP telephony network.

1.1 VoIP Phones

A VoIP phone is a dedicated hardware that connects to a VoIP network. VoIP phones can implement one or more application layer protocols that are responsible of the signaling and transport of voice conversations (SIP, IAX2, SCCP, H.323 etc). The most common mechanism that allows the exchange of VoIP calls is the use of an intermediary capable of locating terminals and route calls between them. This intermediary is known as a PBX.

1.2 WiFi VoIP Handset

A WiFi VoIP handset is a VoIP phone that uses an existing IEEE 802.11 network as the communication channel. A WiFi VoIP handset includes in one single portable unit a VoIP Phone (application) and a Wireless Client (media). The handset takes advantage of the mobility properties of IEEE 802.11 and can handle seamless handovers across a group of wireless network devices using a given "Service Set".

1.3 Analogue Telephone Adaptors

An Analogue Telephone Adaptor (ATA) or a Telephone Adaptor (TA) connects a standard analogue telephone to a VoIP network. An ATA has an RJ-11 (phone jack) and an RJ-45 (Ethernet) jack. An ATA acts like an FXS adapter, talking analogue with the phone and digital with the VoIP network. As VoIP Phones the ATAs can support a variety of VoIP protocols, SIP being the most common one. From the functional point of view an ATA with an analog phone acts like a VoIP Phone.

1.4 Wireless Client

In a managed IEEE 802.11 wireless network, a WiFi wireless client (some times known as AP Client) operates as a client of an access point. A wireless client "associates" with access points and does not accept associations from other wireless clients. A wireless client works as PCMCIA or wireless adapter in a personal computer. Wireless clients are used to create a wireless local loop (WLL), a wireless connection between clients premises and a central hub.

A wireless client can operate in three main modes:

Bridge mode: in this mode the wireless client allows the flow of wired traffic to transparently reach the wireless network.

Routing client: in this mode the wireless client acts as a router between the wireless and the wired network

Nat client: in this mode the wireless client acts also as a router between the wireless and the wired network but also hides the internal IP addresses of the client premises by means of network address translation.

2 Alternatives for VoIP Wireless Clients

The following three options are possible so as to implement a wireless VoIP communication system based on WiFi.

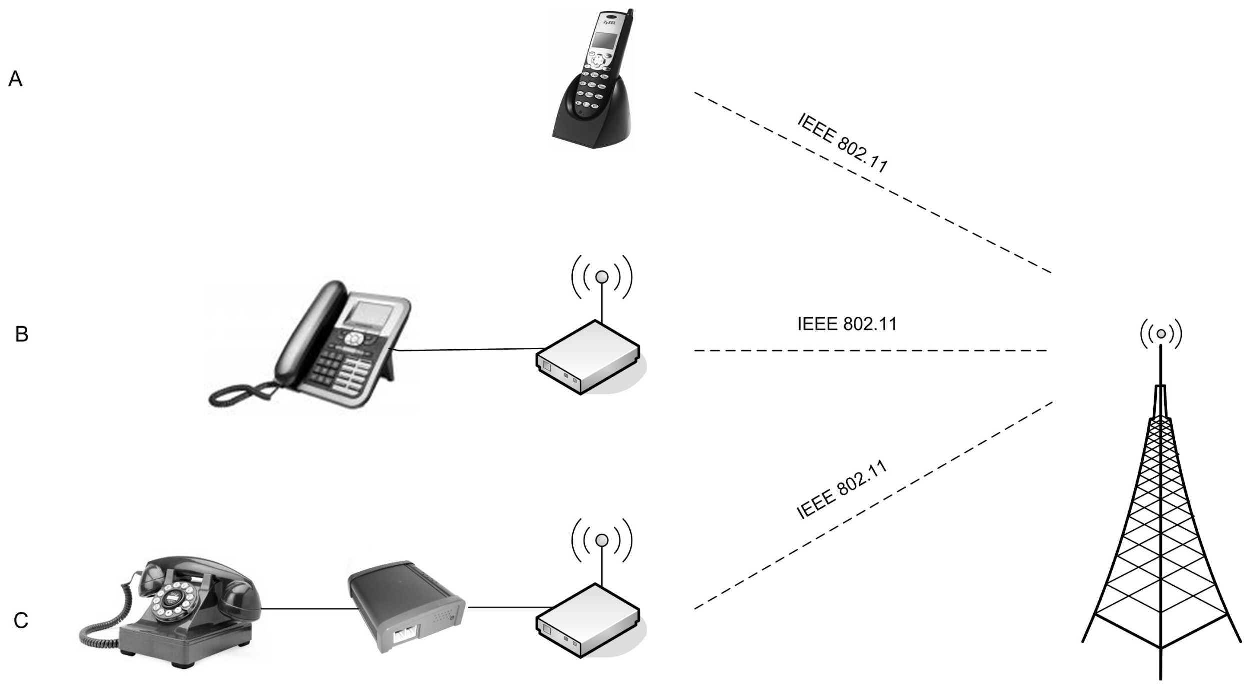

Image 1: Three options for wireless VoIP.

Option A: VoIP mobility
A VoIP handset with support for WiFi. This option offers mobility to the user within the WiFi cell of the base station. Mobility between cells is also possible if they do operate inside of the same service set.

Option B: Wireless Local Loop (WLL) and VoIP (1)
A fix VoIP phone connected to a WiFi wireless client. This option offers WLL but no mobility. A WLL based solution that has line-of-sight between the central station and the clients can provide a coverage of several kilometers.[1]

Option C: Wireless Local Loop (WLL) and VoIP (2)

An analog handset connected via an analogue telephone adapter (ATA) to a WiFi wireless client. This option offers WLL but no mobility.

1 The equipment needs to support optimization for long distances and traffic reservation for real time services (WMM – IEEE 802.11e). Coverage can range anywhere between 1 to 10 Kms depending on LoS.

Table 1 provides a rough estimates of the hardware costs involved in each solution.

Option	WiFi VoIP Handset	VoIP Fix Phone	Analog Phone	ATA	WiFi Wireless Client	RF Cabling Antennas	TOTAL [USD]
A	250						250
B		80			60	60	200
C			40	60	60	60	220

Table 1: Hardware estimations for Option A, B and C for wireless VoIP communication system based on WiFi.

Table 2 compares advantages and disadvantages for each of the options.

Option	Mobility	Internet	Energy Demands	Coverage	Complexity
A	YES	LIMITED	LOW[2] (5 W)	LOW	LOW
B	NO	YES	HIGH[3] (25 W)	HIGH	HIGH
C	NO	YES	HIGH (25 W)	HIGH	HIGH

Table 2: Advantages and disadvantages for different wireless VoIP solutions.

Wireless mobile VoIP handsets (Option A) have the advantage of mobility, low energy demands and a simple setup. The main drawbacks are the limited coverage of a wireles VoIP terminal, reduced autonomy and the limited access to Internet services (Internet support is only available in high-end VoIP handsets or PDAs).

Option B and C allow bigger wireless coverage and the possibility of accessing the Internet at the price of loosing VoIP mobility. These two options have bigger energy demands and a more complex setup. The main difference between Option B and C, is that the possibility of procuring analog phones in the local market instead of importing expensive fix VoIP terminals.

2.1 Voice over IP vs full Internet services

If the business model focuses on voice services Option A is the most suitable of the options as it does not require a 24h powered WLL to each of the clients. If VoIP is part of a group of Internet services, a WLL infrastructure including power backup and surge protections needs to be deployed.

The use of VoIP handsets have the limitation of network coverage and a deterioration of the quality of service as

2 Recharging the handsets

3 The wireless client (15 W) and the ATA/VoIP Phone (10 W) needs to be constantly powered (no power savings). Devices can use different DC currents: 5 V, 12 V, 24 V and 48 V)

the number of nodes increases in the wireless cell. WiFi has not any inbuilt mechanism to provide traffic reservations. Nodes that use IEEE 802.11 (WiFi) share a common communication media, in absence of a mechanism to reserve bandwidth, a node can exhaust all available bandwidth resources. This is the reason why traffic needs to be shaped and the load balanced.

It is difficult to estimate the number of users that will be able to place simultaneous phone calls by a single access point in a disperse rural setup, but the number is not bigger than 10 users per AP assuming usage of the G.711 codec and 15 users for the G.729[4].

2.2 Analysis of Wireless WiFi VoIP Handsets

The following list of characteristics have been identified as relevant for VoIP wireless terminals in rural setups. The most relevant aspects are marked with (*).

Software

- Interoperability: Public protocols (SIP, IAX2) vs Proprietary solutions (SCCP) (*)
- Support for NAT: STUN, symmetric signaling/media
- Low bandwidth: support for high compression codecs (e.g. G.729, Speex) (*)

Audio

- Good echo canceling G.168
- External audio: handsfree
- Configurable Jitter Buffer
- Quality of service: TOS, Diffserv, IEEE 802.11e (*)

Administration

- Administration interface
- Remote provisioning and troubleshooting

Physical design

- Robust mechanical properties (*)
- Dust and Humidity
- External wireless antenna connector (*)

Energy

- Battery charging options
- Autonomy and Power saving (*)

Support & Pricing

- Low price and Guarantees (*)
- Support and Documentation

4 Some companies are trying to overcome some of the limitations of IEEE 802.11 for real time services and include QoS by controlling the airtime. http://www.merunetworks.com/pdf/Enterprise_**VoIP**_WP2-0705.pdf

The following table summarizes some of the quantitative results of 7 wireless VoIP handsets from 4 different vendors.

Model	Company	Indoor/outdoor Coverage [m]	Price 2007 (USD)	Talk Time [h]	Stand-by [h]	Battery	Codecs
F1000 G	UTStarCom		119	4	30-50	120 mA (3 h)	G729 G711
F3000 Clamshell with Color LCD	UTStarCom	70/110	200	3	75	120 mA (3 h)	G729 G711 G726
WIP300- NA Color LCD	Linksys	75/200 (16-18 dbm)	210	N/A	N/A	N/A	G729 G711
WIP330-NA Windows CE	Linksys	N/A <300	349	3	50	N/A	G729 G711 (ToS)
WIP-5000	Hitachi	N/A	310	3.10	55	N/A	G711 G729a
WIP-3000	Hitachi	N/A	274	3.10h (power safe)	55	3h	G711a G729a (11e)
Prestige 2000W	ZyXEL	75/300 (14 dbm)	200	N/A	N/A	N/A	G711 G729a (G.168)

Table 3: A summary of quantitative results of 7 wireless handsets from 4 different vendors.

2.3 Summary of features

The price of a wireless WiFi SIP VoIP terminal ranges from 120 to 350 USD. It is a big variability of costs, the most expensive terminals include color LCDs and Internet functions. A basic terminal that can do VoIP has an autonomy not bigger than 3 hours and 40-50 hours in stand-by. The power requirements are 5 W (15 Wh). The high compression codec G.729 is available in most of the models and outdoor coverage ranges between 100 and 300 meters. A handset can be charged in 3 hours using a 240 AC source and an average current consumption of 120-200 mA.

WiFi handsets do not normally allow the use of an external antenna and coverage is limited by the power and a small gain of the client. In some models, quality of service is implemented indirectly by means of *Diffserv* where voice traffic is subjected to classification. This quality of service might be insufficient if traffic engineering and is not properly implemented in the wireless network.

WiFi VoIP phones do normally support both the IEEE 802.11 b and g standard. Confidentiality of the phone conversations is achieved by means of the native encryption mechanisms of IEEE 802.11 (WEP, WPA).

The majority of all phones reviewed implement SIP (v2) application layer protocol. SIP has the advantage of being the most widespread protocol in terminal devices but has the main drawback of not being simple to use in the presence of NATs.[5] The current trend is to include support for STUN in the handsets. STUN allows the client to discover the public address and port mapping used when operating behind NATs.

If wireless VoIP infrastructure is deployed using SIP, it is highly recommendable that the terminals and the PBX are present in the same subnet or in a fully 'routable' network.

3 VoIP Interconnection

The interconnection of the VoIP handsets requires the use of a Private(Automatic) Branch Exchange (PBX). The PBX sits between the outcoming telephone lines and several wireless phones. The PBX is responsible of redirecting incoming calls to a given phone, or to allow phones to choose a specific operator to place a non-local phone call.

Two main mechanisms could be implemented to connect the internal telephone network to the global telephone network:

A) **PSTN gateway:** In this scenario, an analog PSTN or digital phone line must be present in the area. A dedicated hardware needs to be placed in the PBX to route the wireless VoIP calls to the PSTN.

B) **GSM gateway:** In this scenario, an analog PSTN or a digital phone line must be present in the area. A dedicated hardware needs to be placed in the PBX to route the wireless VoIP calls to the GSM network and vice versa.

C) **Internet gateway**: In this scenario, Internet connectivity must be available and wireless VoIP calls are routed to the global network via another VoIP operator that is present in the Internet which can terminate or transit the calls.

5 http://www.asteriskguru.com/tutorials/sip_nat_oneway_or_no_audio_asterisk.html

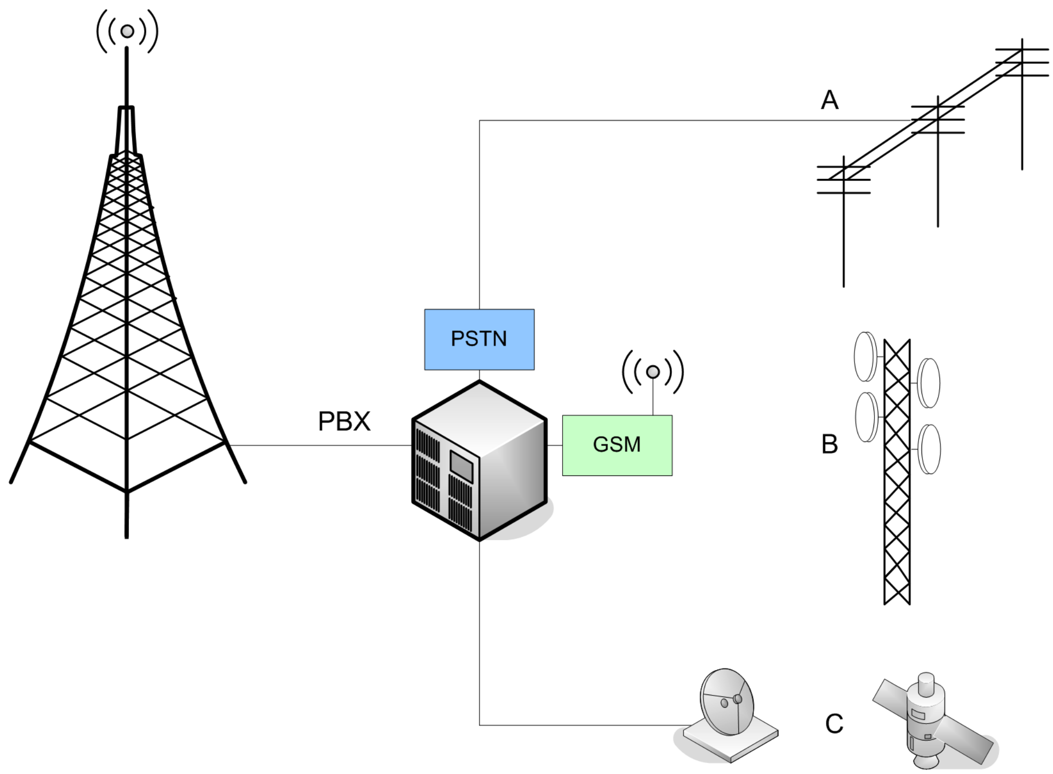

Image 2: Three ways to interconnect a VoIP network.

Table 4 includes the hardware costs of a PBX VoIP gateway using Asterisk (open source PBX) and the different interfaces.

Gateway	Lines	Interface Cost (USD)	Example Hardware	Total Hardware System Cost[6]	Monthly Costs	Energy (24 h)
PSTN	4	1000	TDM400	2500	PSTN Fees	600 Wh
GSM	4	2000	Junghanns GSMquad[7]	3500	GSM Fees	600 Wh
Internet	Nx 32 kbps	0	VSAT Lease Line	1500	Internet Fees	400 Wh + 60 W (1 KWh)

Table 4: Costs (fees and hardware) and example hardware for the implementation of three different gateways for a VoIP network.

6 The total cost of the PBX system does not include the energy backup and surge protections.
7 http://voip-info.org/wiki/view/VOIP+GSM+Gateways

4 DECT as an alternative to WiFi VoIP

4.1 DECT Handset

Digital Enhanced (formerly European) Cordless Telecommunications (DECT) is an ETSI standard for digital cordless phones. DECT uses the codec speech, ITU ADPCM G.726 for full duplex connections. DECT allows a maximum of 12 full duplex conversations in each of the 10 radio sub carriers (1880-1900 Mhz (Europe) or 1920-1930 Mhz (USA)). As DECT operates in another frequency spectrum than WiFi, it does not suffer interference from WiFi equipment. Another advantage of DECT versus VoIP over WiFi is that DECT has strong mechanisms to guarantee quality of service (TDMA vs CDMA). DECT provides a mechanism to negotiate slots and allocate bandwidth in the communication channel.

The fact that the communication slots are "predictable", allows DECT handsets to have better energy savings. A normal handset can feature 12 hours continuous talk time without need of recharging and offers more than 100 hours in standby mode.

The maximum allowed power is 250mW (while the legal limit for IEEE 802.11 is 100mW in Europe). DECT provides confidentiality by means of the DSC Cipher (DECT Standard Cipher).

DECT has an interoperability profile known as GAP that allows (at least in theory) to use any GAP base station with any GAP handset.

There is two alternatives for using DECT to provide wireless VoIP connectivity:

Option A: DECT – ATA

Connect a DECT base station to a VoIP ATA.

Option B: VoIP DECT

Use a DECT handset that implements natively VoIP (see Siemens VoIP DECT[8]).

If only voice services are required, a good alternative worth considering is the use of DECT instead of WiFi for the VoIP. DECT coverage and quality of service are better than any standard VoIP solution based on WiFi.

The network architecture could use WiFi to build the backhaul and DECT with VoIP handsets in the last hop to the user.

8 Siemens Gigaset C450 IP - http://www.voipuser.org/review_41.html

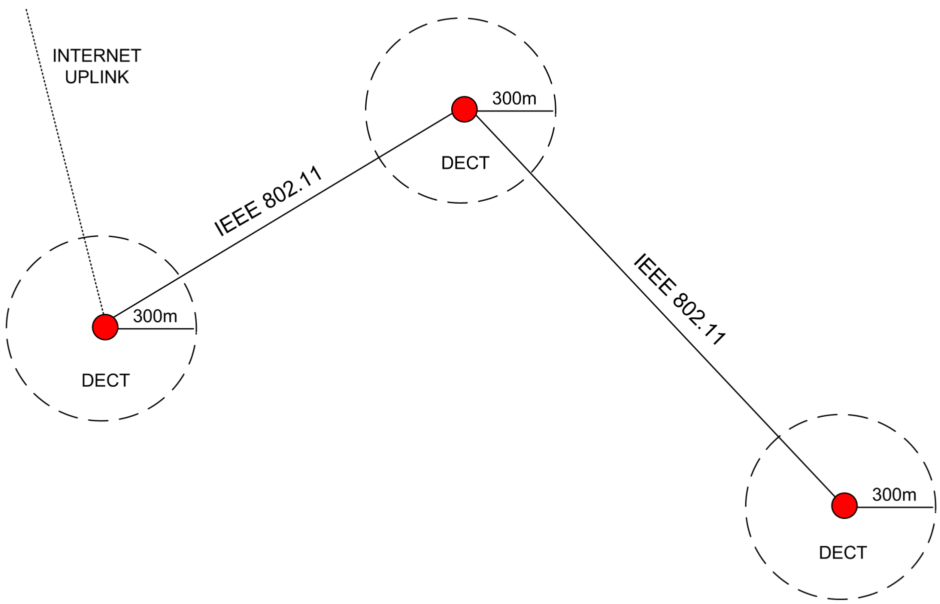

Image 3: A voice/data backbone (WiFi) with local DECT cells (voice).