Application of WiFi in bridging the digital divide in developing countries

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- IEEE 802.11x standards
- FCC Regulations for use of WiFi
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History of WiFi

- WiFi stands for Wireless Fidelity protocol. The Institute of Electrical and Electronic Engineers (IEEE) first introduced standard No 802.11 in 1997.
- The protocol defined three physical layers in the 2.4 GHz and 5.8 GHz frequency band:
  - **Direct Sequence Spread Spectrum (DSSP) at 1 Mbps**
  - **Frequency Hopping Spread Spectrum (FHSS) at 2 Mbps**
  - **Infrared (IR)**

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2.IEEE Standards

- In 1999 the first standard was ratified by IEEE to create two new standards:
  - 802.11a: Orthogonal Frequency Division Multiplexing (OFDM) was added in the 5 GHz spectrum with transmission speeds of up to 54 Mbps
  - 802.11b: was added 5.5 and 11 mbps support using DSSS in the 2.4 GHz making it backward compatible with 802.11 (1 and 2 Mbps) DSS gear
- In 2003 the second standard was ratified to create 802.11g
  - 802.11g: high speed transmission up to 54 mbps by applying OFDM in the 2.4 GHz unlicensed spectrum.
  - The 802.11g is backward compatible with 802.11b by integrating DSSS modulation techniques at 11, 5.5, 2 and 1 Mbps.

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2.1 IEEE 802.11a Standard:

- The 802.11a standard defined 54 mbps wireless system at 5.8 GHz with 12 non-overlapping channels.
- The systems using this standard have a lower range compared to 802.11b.
- The advantage is that the systems are less prone to electromagnetic interference from other cordless devices.
- These systems can be used for
  - building to building and for
  - backhaul applications where there is line of Sight.
- The disadvantages of 802.11a are those of short range and higher cost compared to 802.11b systems.

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802.11a Channel Numbering

Channel	Center freq.(MHz)
36	5180
40	5200
48	5240
52	5260
56	5280
60	5300
64	5320
149	5745
153	5765
157	5785
161	5805

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2.2 IEEE 802.11b Standard:

- **The 802.11b systems are manufactured for use in the 2.4 GHz ISM band with 11 non-overlapping channels.**
- **The range of the systems varies depending on the transmitter power and antenna gain.**
- **The maximum transmission speed is 11 Mbps auto negotiable down to rates of 5.5, 2 and 11 Mbps as the signal strength deteriorates.**
  - **The advantages of 802.11b systems are:**
    - **(a) high range and**
    - **(b) less expensive**

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802.11b channels:

Ch Number	Center Freq. MHz
1	2412
2	2417
3	2422
4	2427
5	2432
6	2437
7	2442
8	2447
9	2452
10	2457
11	2462
12	2467
13	2472
14	2484

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2.3 IEEE 802.11g Standard

- **IEEE 802.11g standard defines systems that are made to OFDM and DSSS modulation technology in the 2.4 GHz with a maximum transmission speed of 54 Mbps.**
- **These systems are normally used as repeaters and backhaul applications.**
- **The systems are backward compatible with 802.11b equipment. 802.11g have only three non-overlapping channels**

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3. FCC Regulations for use of WiFi

- **FCC stands for Federal Communication Commission (USA)**
- **802.11 requirements:**
  - Operates in the unlicensed spectrum- Industrial, Scientific and Medical (ISM) band
  - No monthly or yearly service fee in USA
  - Not free from regulation

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Unlicensed Bands

- ISM Bands: Industrial Scientific & Medical

  902 to 928 MHz

  2400 to 2485 MHz

  5725 to 5850 MHz

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3.2 Unlicensed National Information Infrastructure (U-NII Bands):

- 5150 to 5250 MHz up to 50 milli Watt transmit power (40 mW IEEE)
- 5250 to 5350 MHz up to 250 milli Watt transmit power (250 mW, IEEE)
  - These bands are designed for wireless data networking and internet to schools in USA.

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3.3 FCC Rules: EIRP Limits for WiFi

- (a) Point to Point systems in the 2.4 to 2.5 Ghz: 36 dBm (4 Watts)
- (b) Point to multipoint in the 2.4 to 2.5 Ghz: 30 dBm (1 watt)
- © For every 3 dBi of antenna gain over 6dBi, the transmitter output power must be reduced by 1 dB

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Link Budget

- Transmitter power + Transmit antenna gain + Receive antenna gain + Receiver gain- Free Space Loss (FSL)

  Whereby:
  - **FSL= 20 * log 10 (F/MHz) + 20 log10 (D/Miles) + 36.6**
  - **Freznel Zone= 72.1 * Sqrt(D1*D2/F GHz) * D**
  - **Link Margin= (RSL – RX Sensitivity) dB or SNR**

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Link calculation

- Here is a simple table of path loss calculations in free space for channel 1 with clear line of sight (the difference in path loss from channel 1 to channel 11 is negligible).
- Distances are in miles;
- losses are in dB.

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Path calculation table

Distance (miles)	**Losses Ch 1 dB**
0.5	98
1	104
2	110
3	114
4	116
5	118
7	121
10	124
15	128
20	130
25	132
25	134

» L = 20 log(d) + 20 log(f) + 36.6

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4. WiFi Networking

- Can be used to bridge missing links in access networks and trunk networks in rural and suburban areas
- Can be offered as a free internet service in hotels, airports, cafes, universities (hot spots)
- Can attract new customers for ISPs and Data Operators
- Are relatively cheap compared to traditional microwave systems
- Offer high speed and bandwidths
- Can provide data and voice services where there is no telecom presence

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Advantages of WiFi

- No license fees
- Easy to install
- Secure air interface
- Higher level encryption software on the APs and server
- Host based firewalls for APs and client PCs
- Antivirus bundles
- Anti spyware applications
- Up to date patches

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Network Modes:

- **Adhoc mode or peer to peer mode:**
  - **In this mode there is no Access Point in the network. It is also called Independent basic Services Set (IBSS). All client devices communicate directly with each other**
- **Infrastructure mode:**
  - **In this mode all client devices communicate with each other via an Access Point -The AP is connected to a wired infrastructure e.g a DSL. This type of network is also called Basic Service set (BSS).**

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Components of WiFi Network

Access Points

- » Off the shelf single board embedded computers
- » Run on Windows or Linux

- Wireless Client Devices
  - Notebook computers
  - PCMCIA cards
  - Mini PCI Cards without integrated antennas
  - Desktop PCs
  - PCI Cards with integrated antennas
  - USB devices for desktop PCs
  - Wireless Ethernet bridge
  - PDAs
  - Compact Flash Cards & Secure digital IO cards

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Case Study/applications:

- **WiFi based Wireless Internet Infrastructure**
- **WiFi for high speed data transmission at 5, 11,54 ,108 Mbps**
- **WiFi for mobile backhaul**
- **WiFi for Internet to schools**
- **WiFi for Telemedicine**
- **WiFi for community networks**
- **WiFi for hot spots in hotels, Airports etc**
- **WiFi for Campus WANs**

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WiFi Internet Infrastructure

- **WiFi (Wireless Fidelity) is basically a generic term for wireless LAN equipments, also known as WLAN. It normally confirms the standard IEEE 802.11 family and, thus, supported by many vendors.**
- **Why WiFi based Wireless Internet Infrastructure? There are few simple answers, i.e:**
  - **Wireless for bypassing the need of costly & slow telephone line for accessing the Internet.**
  - **Wireless is easy to deploy.**
  - **It requires a much lower cost in the long run, rather than rely on Telco's infrastructure.**
  - **WiFi is basically a Wireless LAN and, thus, it runs at higher speed 1-11Mbps if the standard IEEE 802.11b is used.**
  - **Since IEEE 802.11b is an open standard, WiFi equipments can be obtained easily in the market. Today, it costs only about 3-4 times a UTP LAN cards & going down.**
  - **Having last mile telecommunication infrastructure solved, next best thing to do is sharing the access to the surrounding neighborhood & share the access fee to reduce the cost per subscribers.**

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Example of WiFi Link

- **WiFi link Trieste to Muggia across the Adriatic Channel in Italy**
  - **Link distance; 25 Kilometers**
  - **Transmitter Power: 25 dB**
  - **Antenna gain: 23 dB**
  - **Link speed: 11 mbps**
  - **Equipment used : Metrix Radio**
  - **Total Link cost: US $ 5000**

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Some of the Basic Assumptions

- **Knowing that WiFi equipment has a limited communication range about 5-8 km due to its low power, some basic assumptions imposed, e.g.,**
- **It is basically to by pass last mile Telco infrastructure, about 5-8 km distance.**
- **The Access Point may be located at Internet Service Provider (ISP).**
- **As for the Internet Service Provider (ISP), their Internet links may use different telecommunication media especially for long distance links. Some of the examples as**
  - **Optical fiber.**
  - **Microwave links.**
  - **VSAT links.**

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Price Estimate of A WiFi System

- Access Point US$62-130
- Pigtail US$30
- Coax US$90-130
- Sectoral Antenna US$500-800
- Omni Antenna US$150-240
- Total Investment US$330-1100

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WiFi Alliance

A society of wireless industry

– **Functions:**

- performs interoperability tests on 802.11 equipment before issuing WiFi trademark
- serves as non-profit industry advocate
- gives assurance to consumers that an Access Point (a) purchased form one manufacturer will work with a PCMCIA card from another manufacturer

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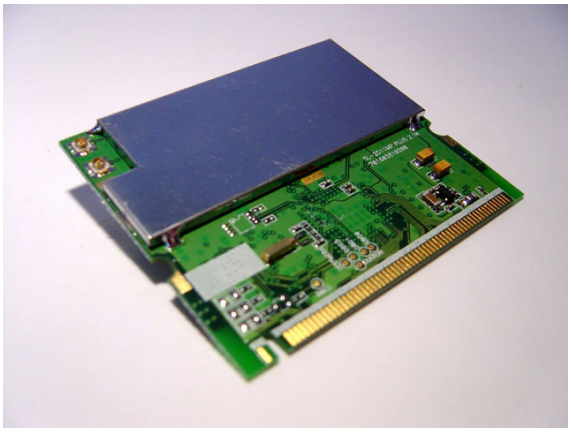
WiFi Radio card

- **Embedded pc**



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WiFi Radio opened

- **Radio**

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Power over Ethernet

- **Ethernet power adapter**

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Outdoor Enclosures

- **Radio enclosure**

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Complete radio kit

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WiFi products

- **More radio cards**

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Access Point

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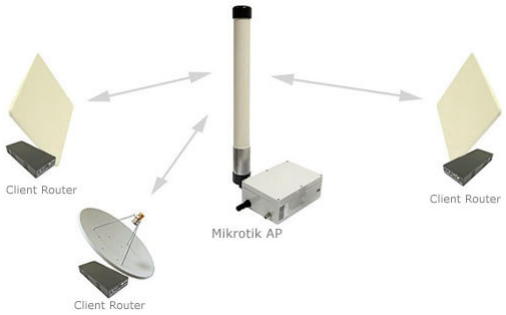
Point to multipoint WiFi

- **Access Point**



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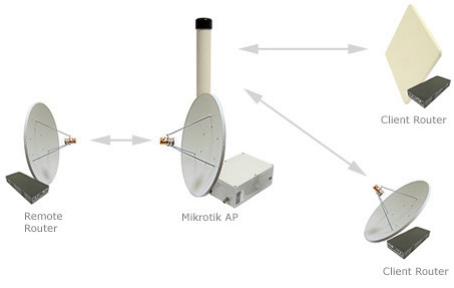
WiFi as backbone

- **Backbone link**



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Access Points

Wireless 2.4GHz (802.11b) Router
DI-514

Up to 11Mbps and fully compatible with 802.11b*

Tri-Mode Dualband 802.11a/b/g (2.4/5GHz) Wireless 108Mbps* Router
DI-784

Up to 108Mbps and fully compatible with 802.11a/b/g*

High-Speed 2.4GHz (802.11g) Wireless Router
DI-524

Fully compatible with 802.11b

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Way Forward & Conclusions

- **WiFi systems are useful for providing connectivity in rural and sub-urban areas where there is lack of access for Internet and data.**
- **WiFi networks can be rapidly deployed in Africa**
- **WiFi systems are cheap compared to traditional digital radio systems**
- **WiFi systems use license free bandwidths in the 2.4 and 5.8 Ghz for high speed data communication for communities, schools, health care, research and scientific applications**
- **WiFi systems can bridge the missing digital link for the user and the service provider**
- **The regulators should not stop communities and scientists from using WiFi to communicate where there is no other means of communication**
- **Operators could consider using WiFi for network deployments**

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