

# HF radio links for Rural Telemedicine Systems in Developing Countries



Foro de Salud Hispano Americano de Salud  
[www.ehas.org](http://www.ehas.org)

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**February 2005**

# *EHAS Foundation*

## **What is EHAS?**

**The EHAS foundation is a non-profit institution, whose ultimate goal is to contribute to the improvement of public health assistance services in rural areas of Spanish American countries (but also develops useful technology for all developing country)**



Enlace Hispano Americano de Salud

[www.ehas.org](http://www.ehas.org)



# *EHAS Foundation*

## **How it does?**

**Improving work conditions for rural healthcare personnel with appropriated telemedicine systems**

- **Telecommunications infrastructure in rural establishments, particularly those that are the most isolated and lack phone line access.**
- **Provision of information services for the healthcare system, aiming to offer:**
  - **Access to distance learning and qualification courses**
  - **Improving epidemiologic surveillance**
  - **Consultation to off-site personnel and medical experts**
  - **Remote access to specialized medical information**

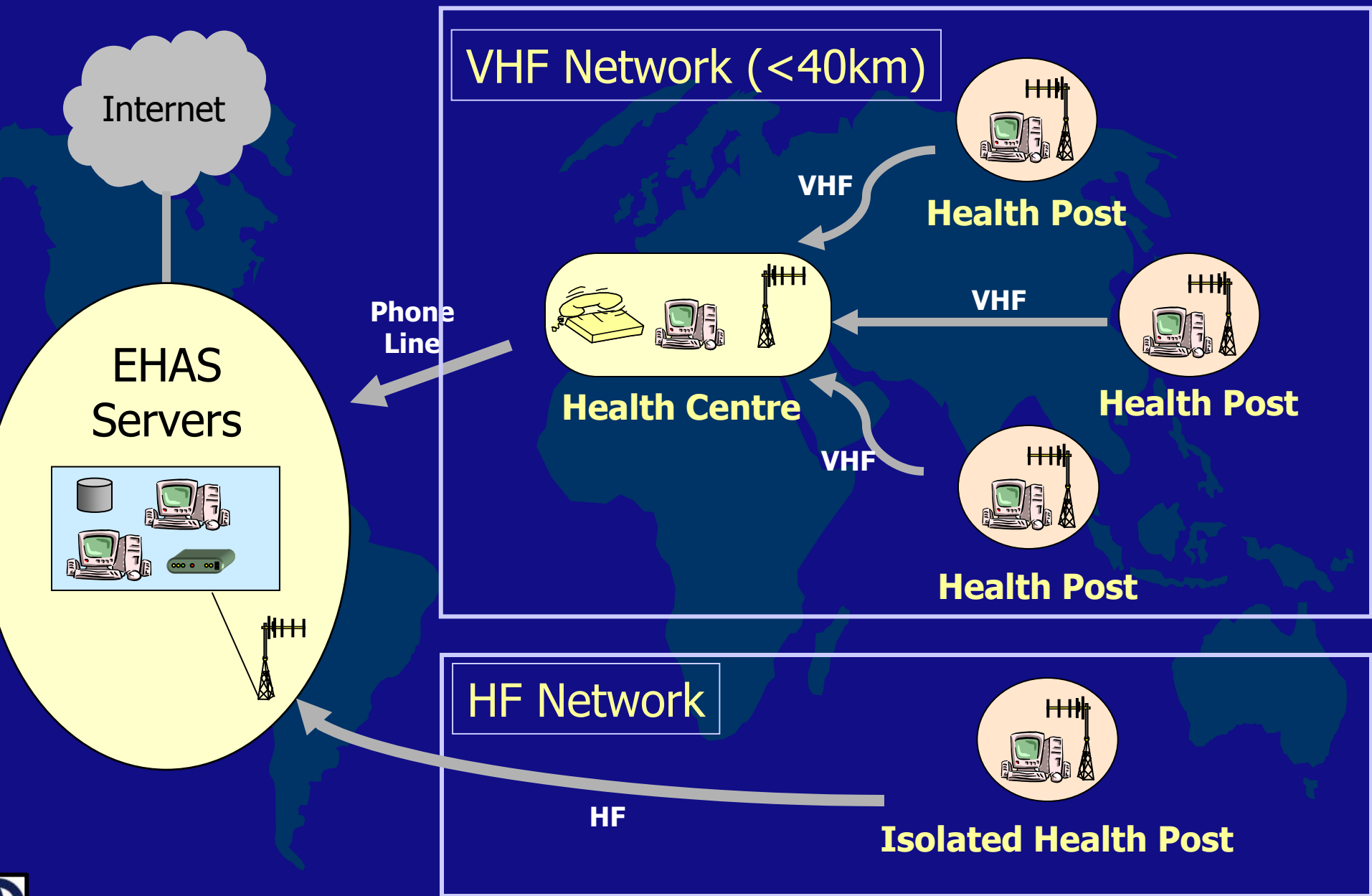


# *EHAS Foundation*

## **Working lines**

- **Low cost communication hardware developing (voice and data).**
- **Introducing communication services and providing access to medical information.**
- **Introducing EHAS networks in real projects.**
- **Evaluation of the Impact on Rural Healthcare Workers.**





Internet

### VHF Network (<40km)

Health Post

VHF

Phone Line

VHF

Health Centre

Health Post

VHF

Health Post

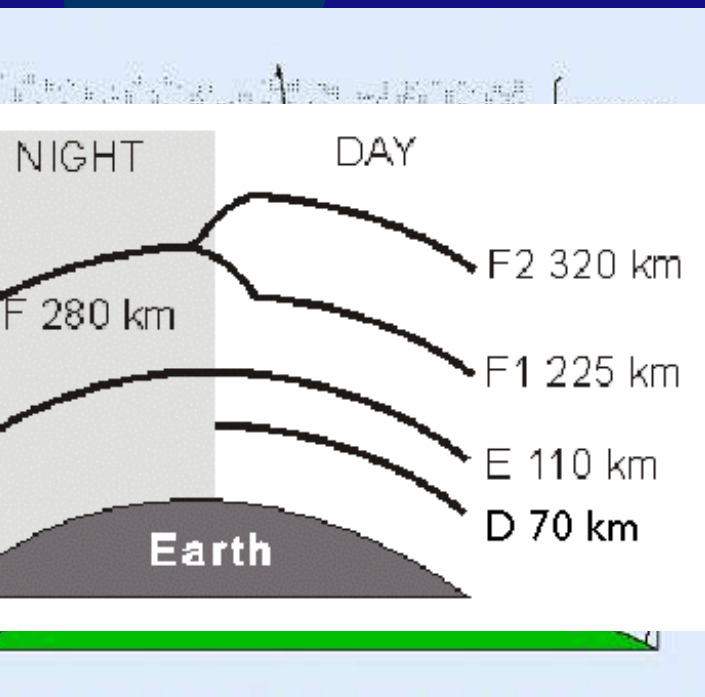
### HF Network

Isolated Health Post

HF



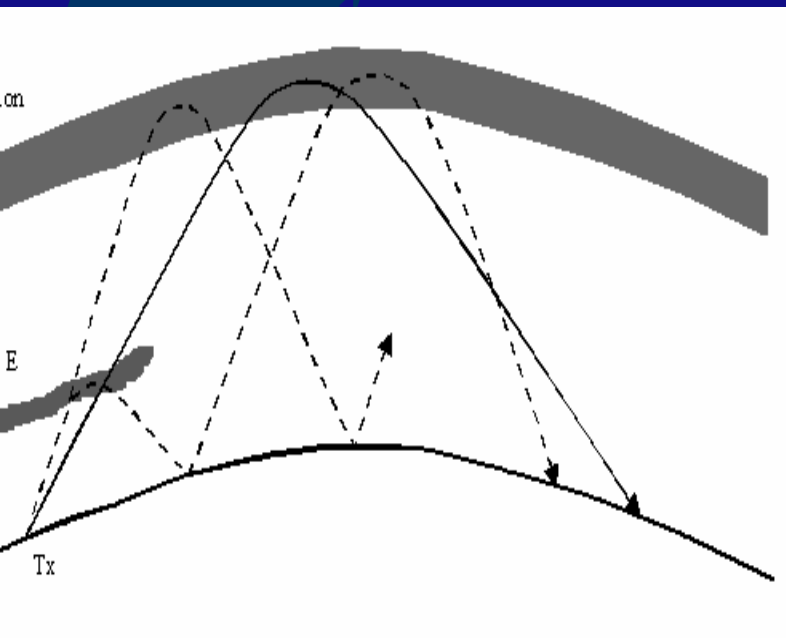
# HF Communication Introduction



- **Frequencies from 3 to 30 MHz**
- **Global communication coverage**  
(cheaper than satellite communications)
- **Surface/Ionospheric propagation**
- **Unreliable and interrupted channel**
  - Time of day (day/night) -> D/F layer
  - Season -> E layer
  - Sunspot activity (11-year-cycle)
  - Ionospheric storms



# HF Communication Propagation issues



- **Absorption** (D-Layer for  $f < 7$  MHz at daytime)
- **Atmospherical noise**
- **Multipath** -> **Selective Fading**
- **Skip zones**
- **Critical frequencies:**
  - **MFU: Maximum Usable Frequency** (different for each layer)
  - **LFU: Lowest Usable Frequency** (due to daytime D-Layer absorption)



# HF Communication Comercial Transceivers

## Main manufacturers

- **Kenwood**
- **ICOM**
- **Yaesu**



Yaesu FT-600



# HF Communication

## Commercial modems

- **Amateur TNC (Terminal-to-Node Controller)**
- **SCS PTC-II**
- **Clover 2000**
- **CODAN 3012**



# Commercial HF Modems

## TNC



- **Modulation: 2-FSK**
- **Raw Data Rate: 300 bps**
- **Cost ~ 100 \$**
- **Designed for VHF/UHF band**

**(Discarded)**



# Commercial HF Modems

## SCS PTC-II

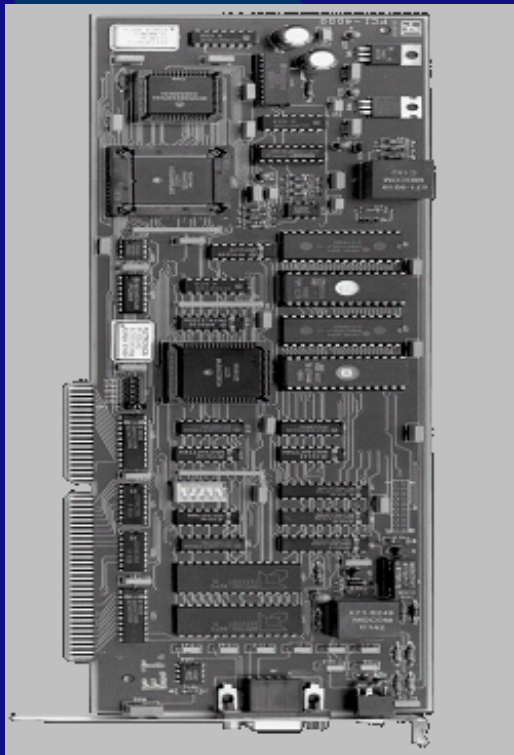


- **OFDM Modem**
- **Modulation: DQPSK**
- **Bandwidth: 2200 Hz**
- **Raw Data Rate: 200 to 3600 bp**
- **Error correction**
- **Cost ~ 1000 \$**



# Commercial HF Modems

## Clover 2000



- **OFDM Modem**
- **Modulation: BPSK to 16-PSK**
- **Bandwidth: 2000 Hz**
- **Raw Data Rate: 375 to 3000 bp**
- **Error correction**
- **Cost ~ 1500 \$**



# Commercial HF Modems

## Codan 3012



- **OFDM Modem**
- **Modulation: QPSK**
- **Bandwidth: 2400 Hz**
- **Raw Data Rate: 2400 bps**
- **Error correction**
- **Cost ~ 6000 \$**



# Commercial HF Modems

## Conclusion

### Advantage:

- Specially designed for shortwave channels and HF transceivers.

### Disadvantages:

- High cost
- Proprietary protocols

### What we want:

- Free GNU modem
- Low Cost:  
Software modem



# Free HF Modems

## Requeriments:

- Free + Software Modem



## Soundmodem:

- GNU/GPL license
- Uses standard soundcard to modulate/demodulate
- HF Modem: *NewQPSK*

## Soundmodem



FSK

PSK

P3D

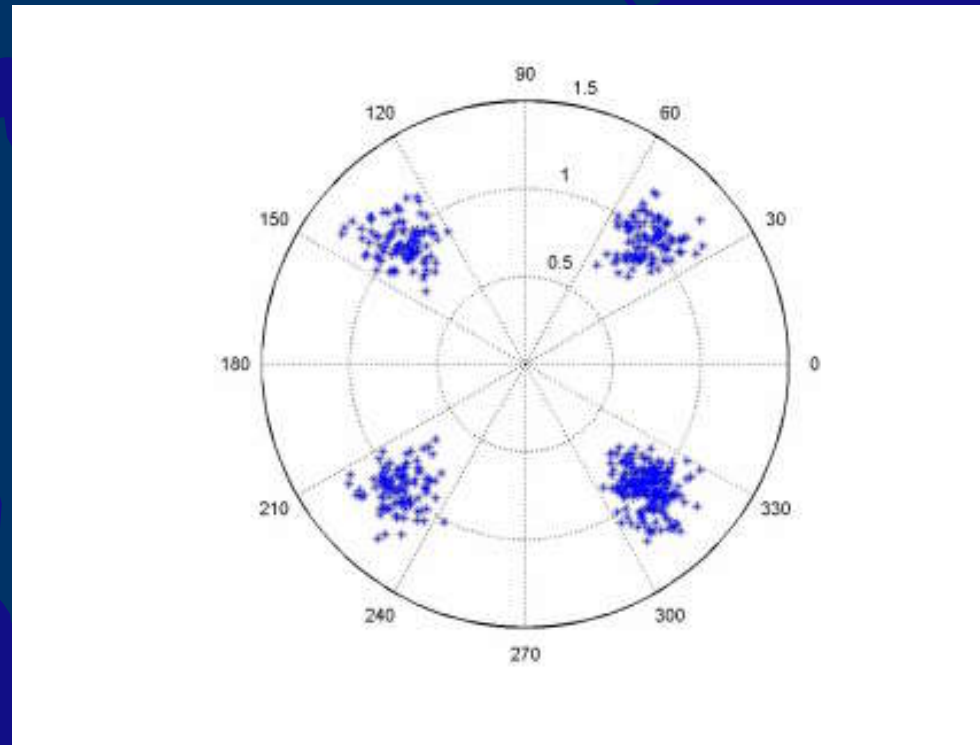
PAM

NewQPSK

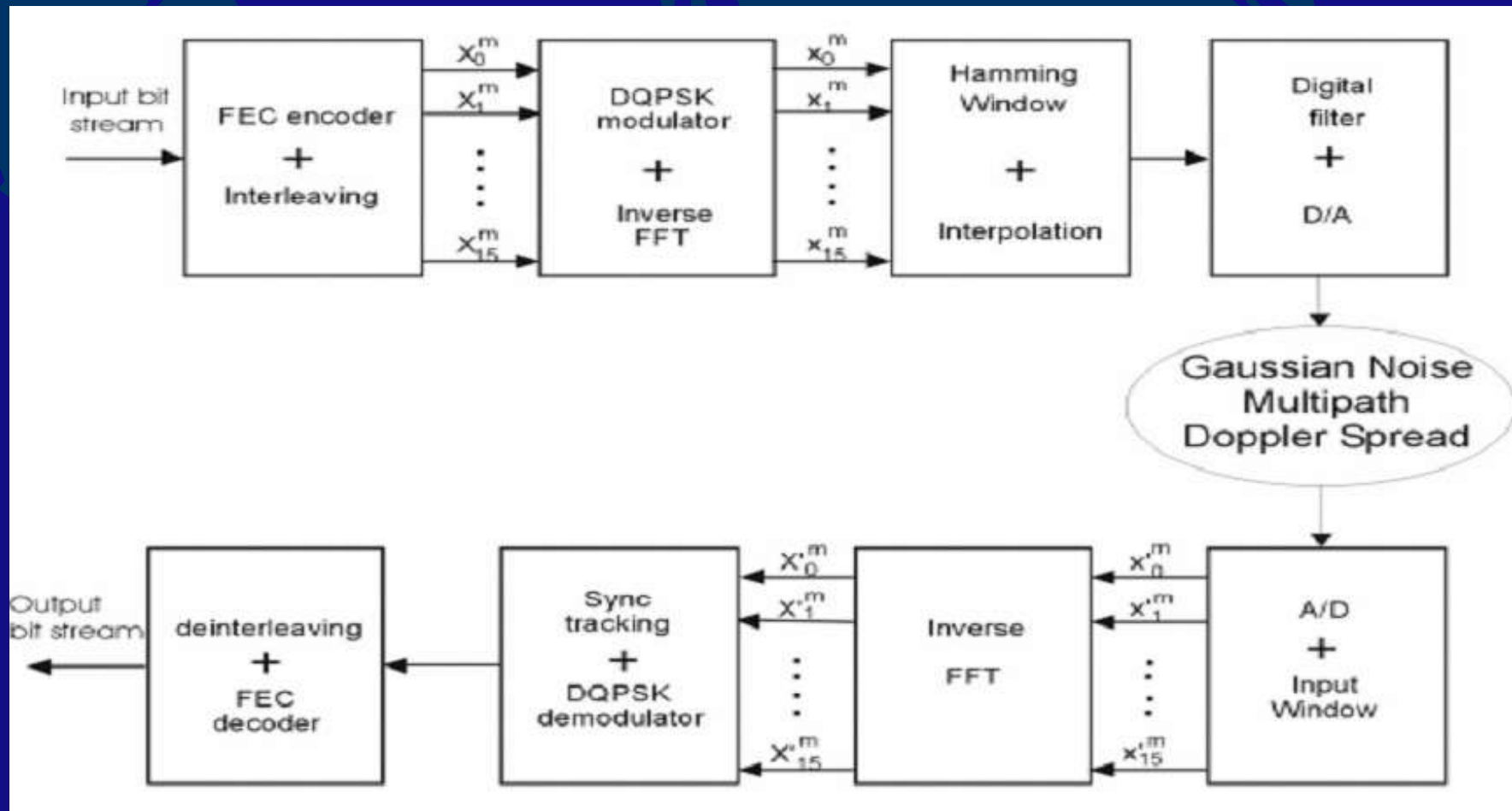


# HF Modem: Newqpsk

- **OFDM Modem**
  - **15 carriers / 2000 Hz**
  - **DQPSK modulation**
  - **Low multipath distortion**
- **Raw speed: 2500 bps (83.3 symbols/sec)**
- **Error Correction: BCH (Block codes)**



# HF Modem: Newqpsk Block diagram



# HF Modem: Newqpsk

## Packet structure

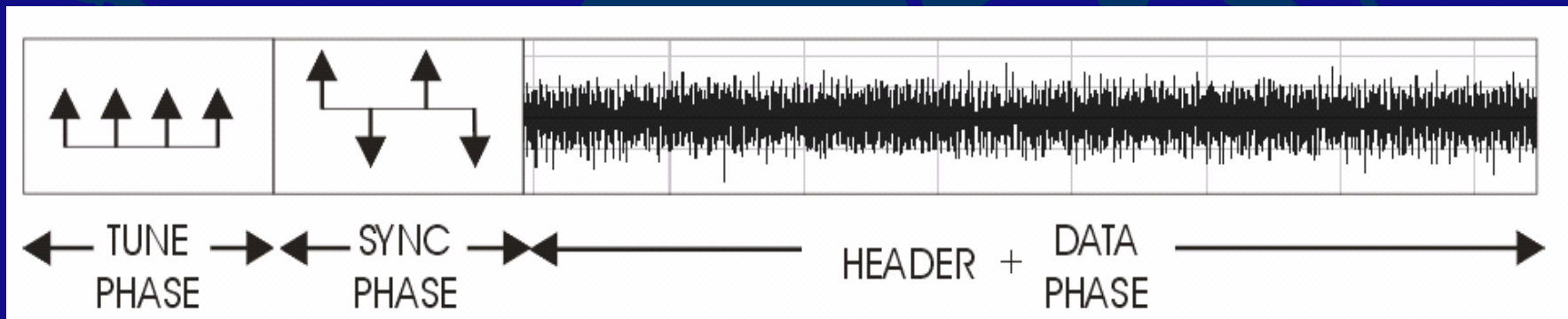


- **Tune Phase:** *380 msecs*
- **Sync Phase:** *380 msecs*
- **Header:** *12 msecs. (Packet length, FEC level)*
- **Data Phase:** *< 10 secs*



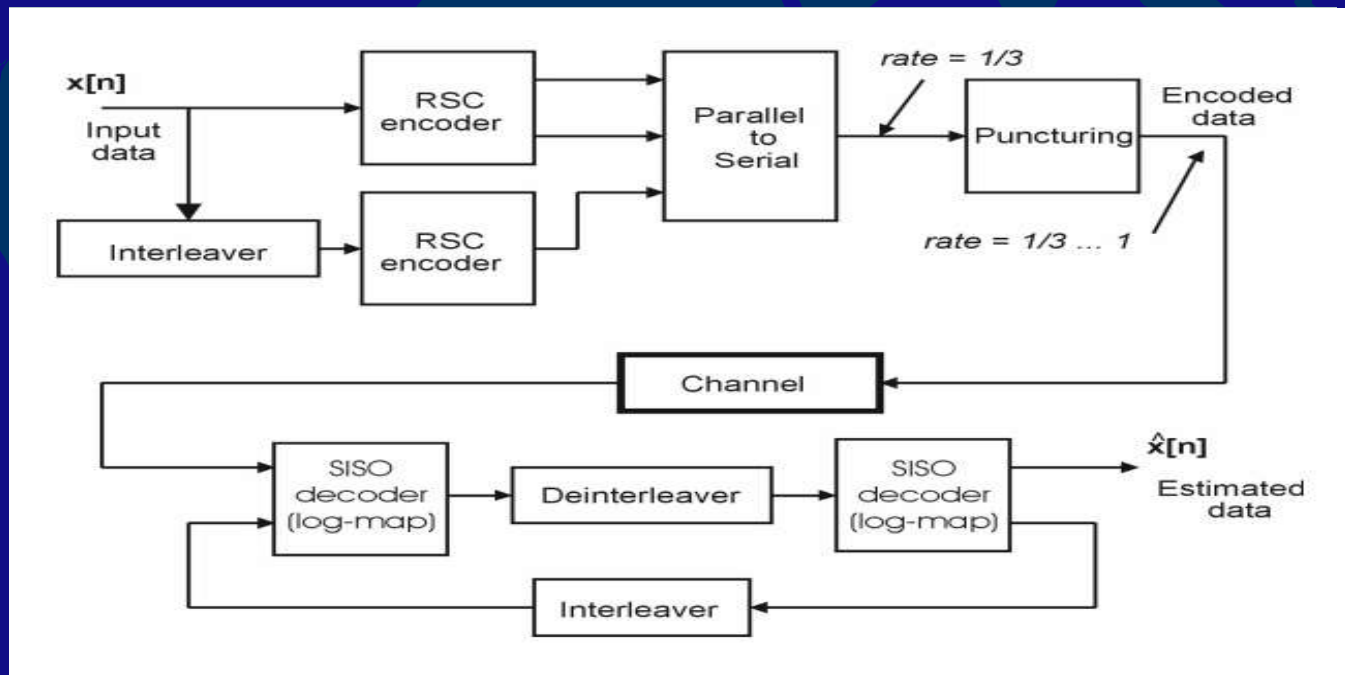
# HF Modem: Newqpsk Modifications

- **Stronger Header Protection**
  - *Interleaved header*



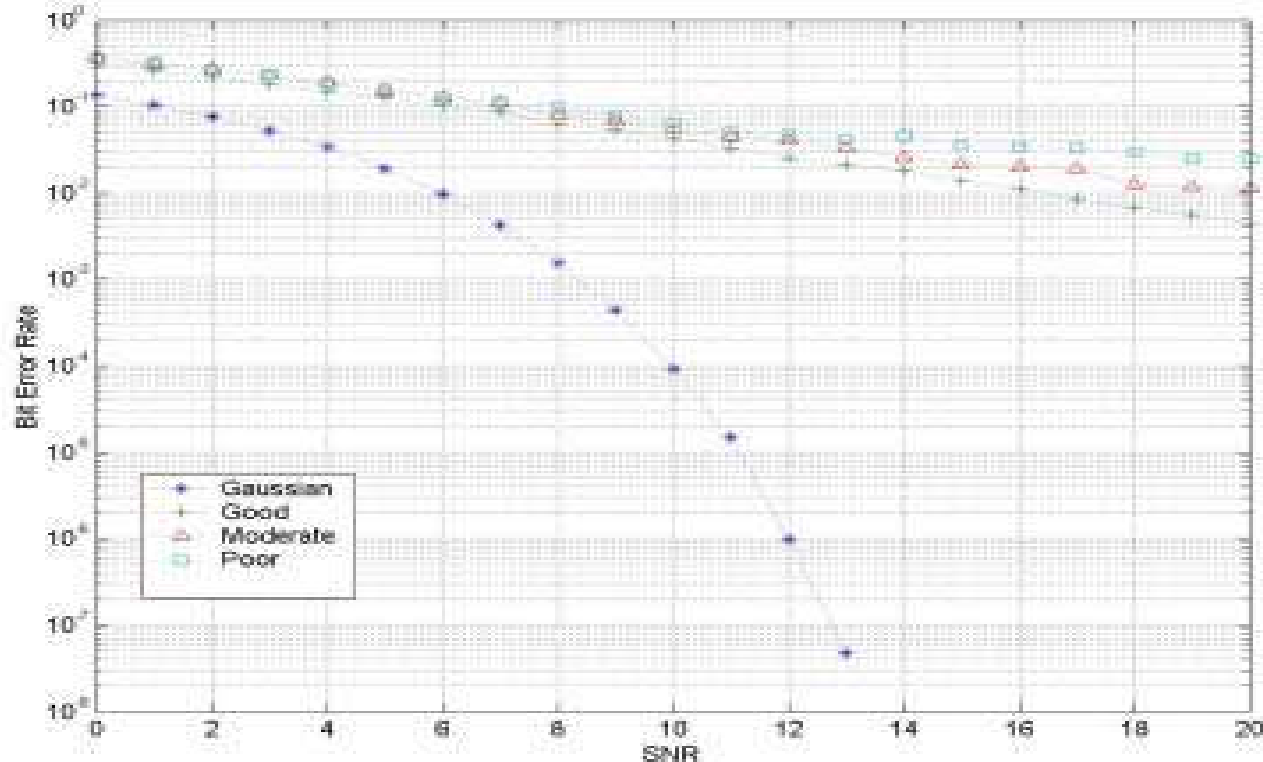
# HF Modem: Newqpsk Modifications

- **Enhanced Error Correction: Turbo Codes**
  - Algorithm performance very close to Shannon Limit
  - Encoding rate: from 1 to 1/3



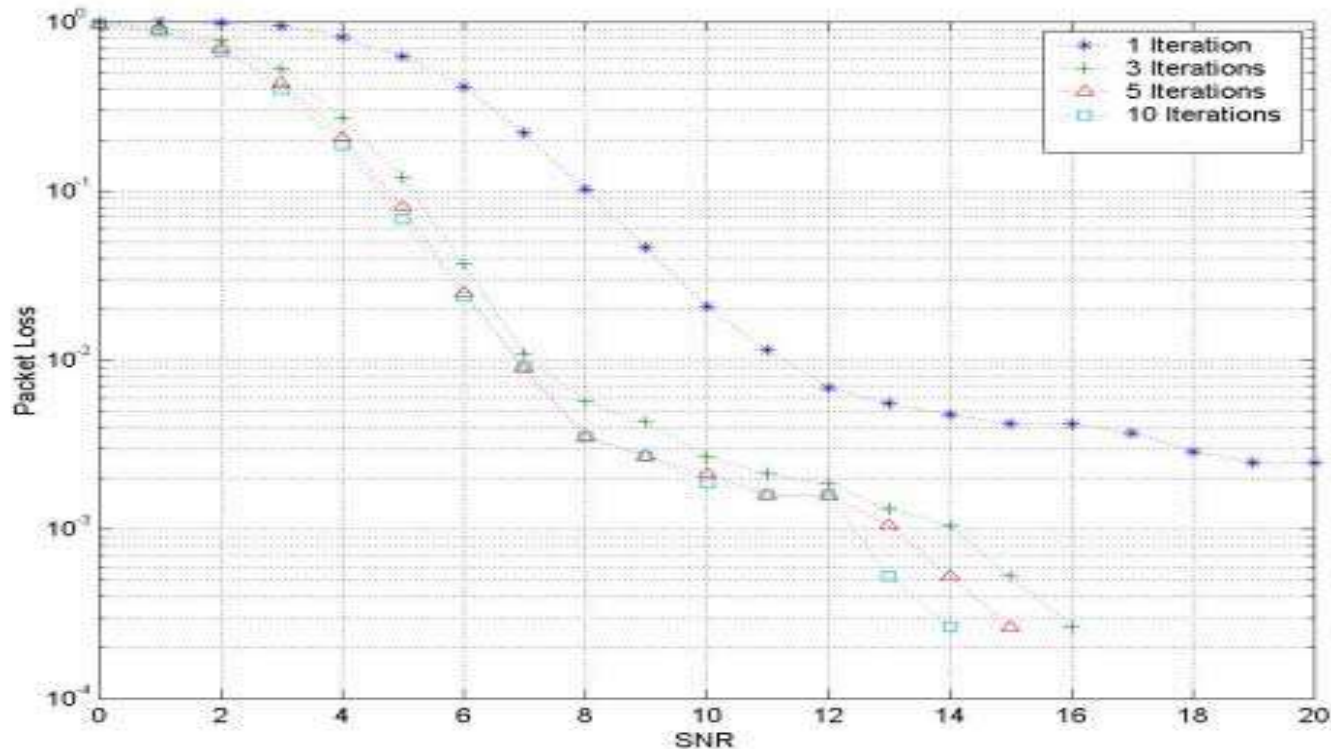
# HF Modem: Newqpsk Performance

- Bit Error-Rate for CCIR Channels (G/M/P)



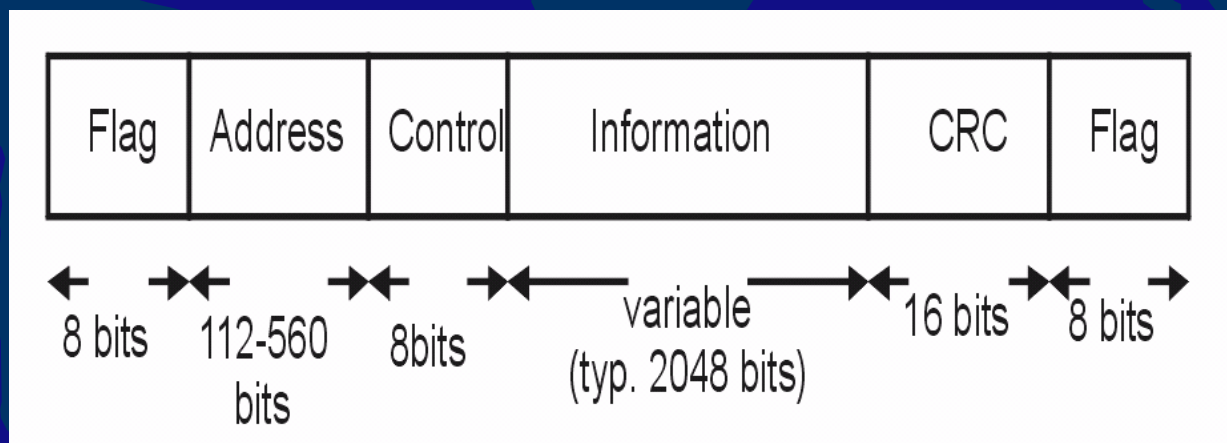
# HF Modem: Newqpsk Performance

- SNR vs Packet Loss (1/3/5/10 iterations)



# Link Protocol: AX25

- **Amateur X.25: Radio Link Layer Protocol**
- **Packet-switching with connected mode**
- **Error-free and packet order assured**
- **Free protocol (included in Linux Kernel)**



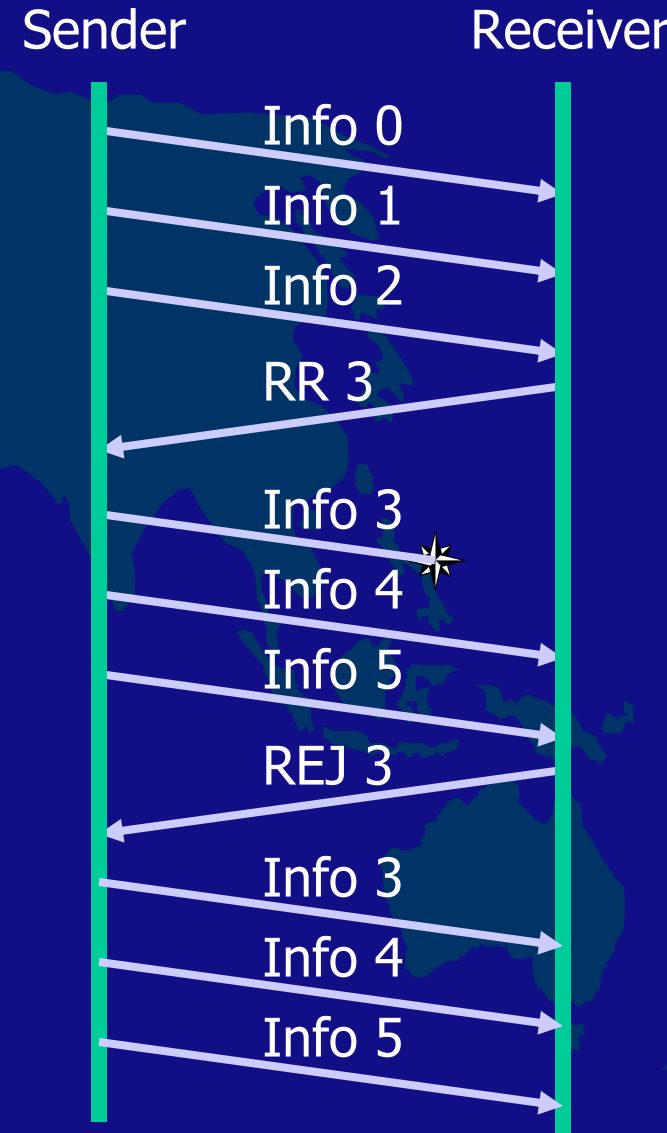
# Link Protocol: AX25

## Modifications: ARQ

### ARQ: Automatic Repeat Request

- **Go-Back-N:** All info packets are asked to resent from a lost one. Very inefficient for high bit-error-rate channels.

*Linux Implementation*

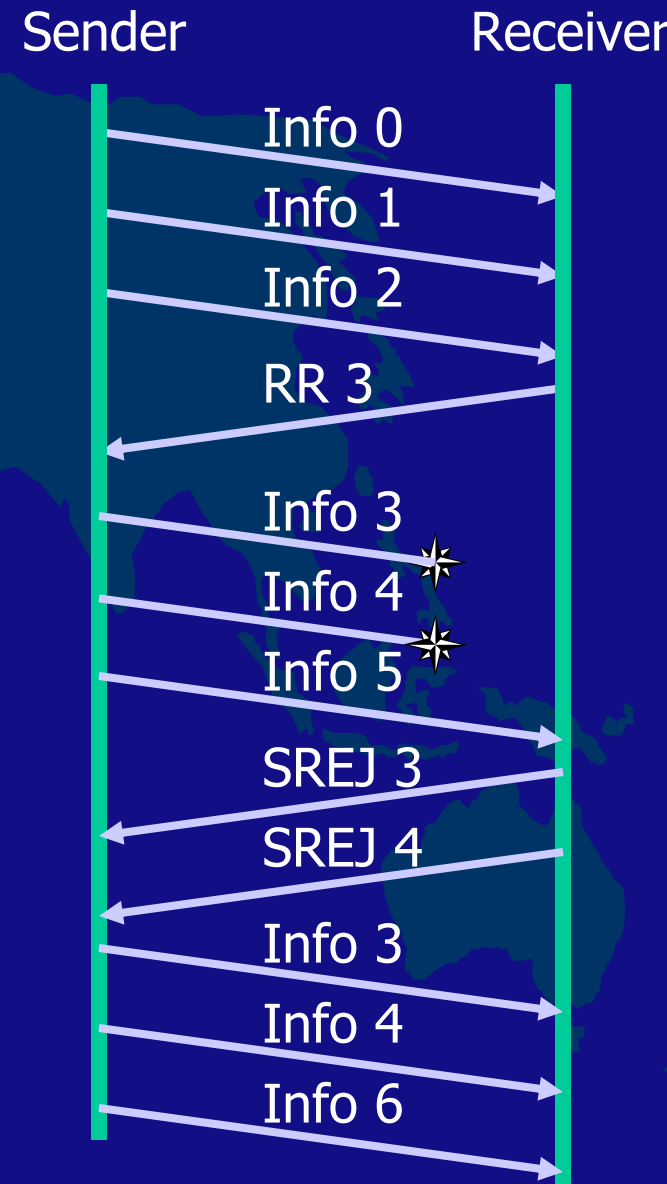


# Link Protocol: AX25

## Modifications: ARQ

- **Selective REJECT:** Lost Packets are asked to reset with individual SREJ commands.

*AX25 Version 2.2 Specification*

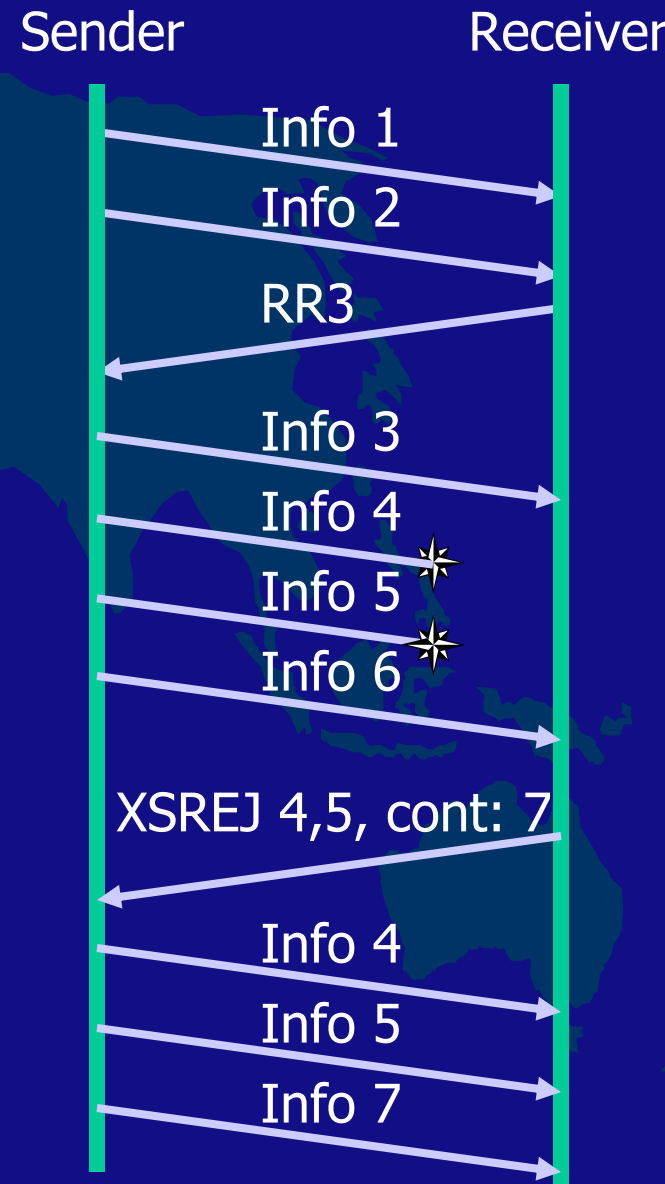


# Link Protocol: AX25

## Modifications: ARQ

- **eXtended Selective REject:**  
Lost Packets are individually asked to be reset with a unique XSREJ command.

### *EHAS Implementation*



# Link Protocol: AX25

## Modifications: DAMA

### **DAMA (Demand Assigned Multiple Access)**

- **Used for sharing the use of bandwidth among multiple users**
- **Uses TDM (Time Division Multiplexing)**
- **Server gives/removes turn to connected users**



# Link Protocol: AX25

## Modifications: DAMA

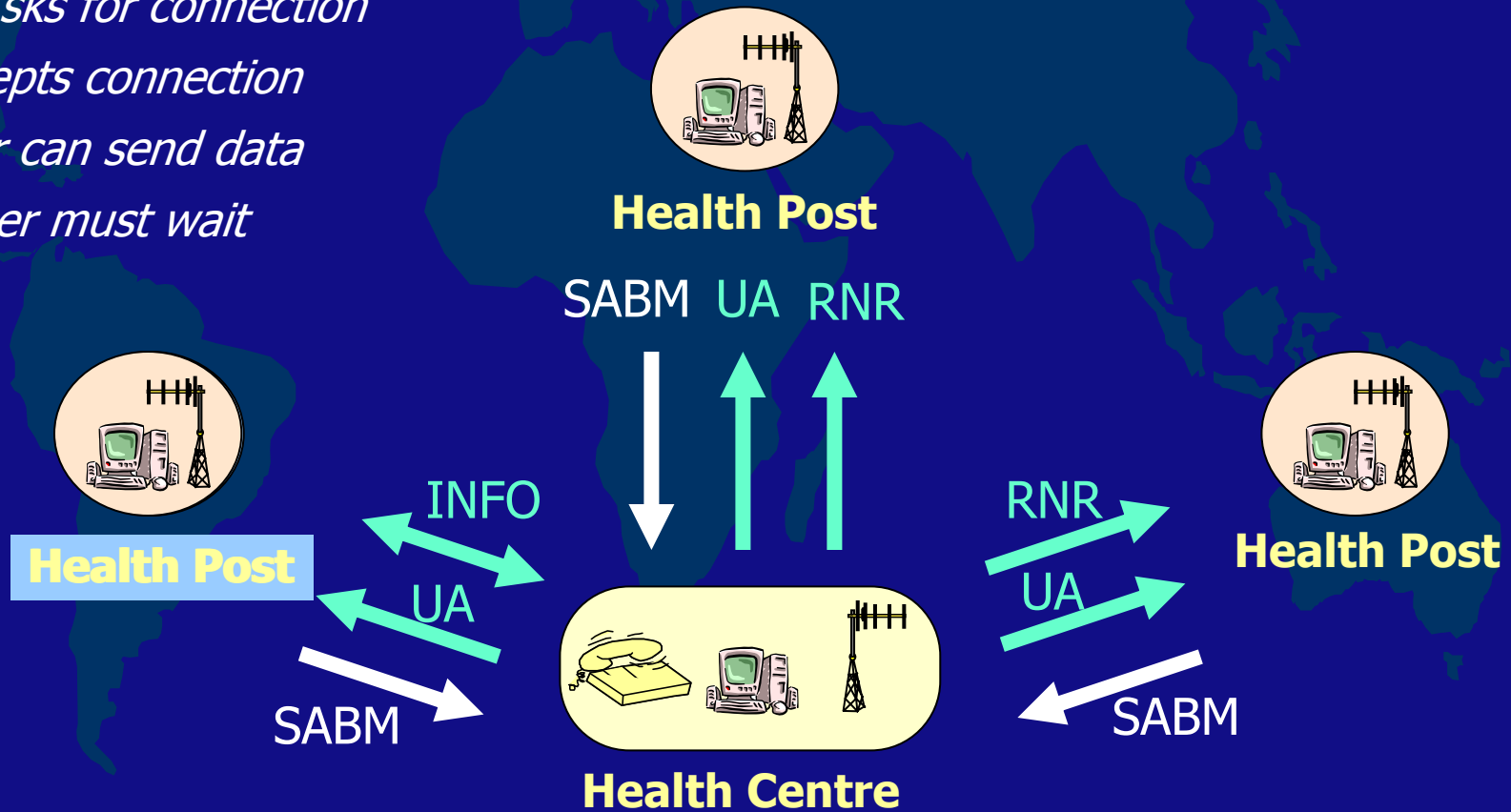
### AX25 packets

SABM: *Asks for connection*

UA: *Accepts connection*

RR: *Peer can send data*

RNR: *Peer must wait*



# Link Protocol: AX25

## Modifications: DAMA

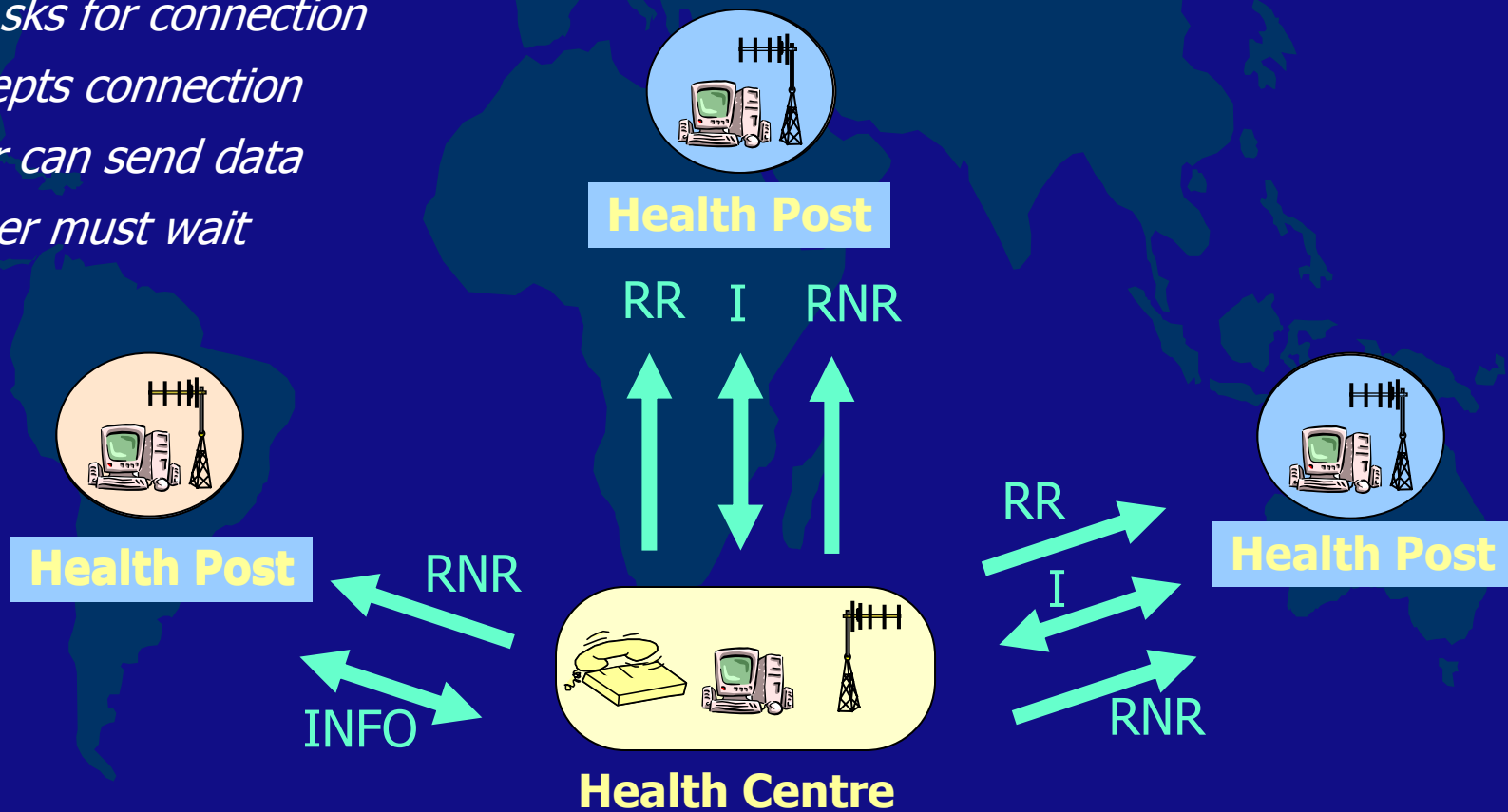
### AX25 packets

SABM: Asks for connection

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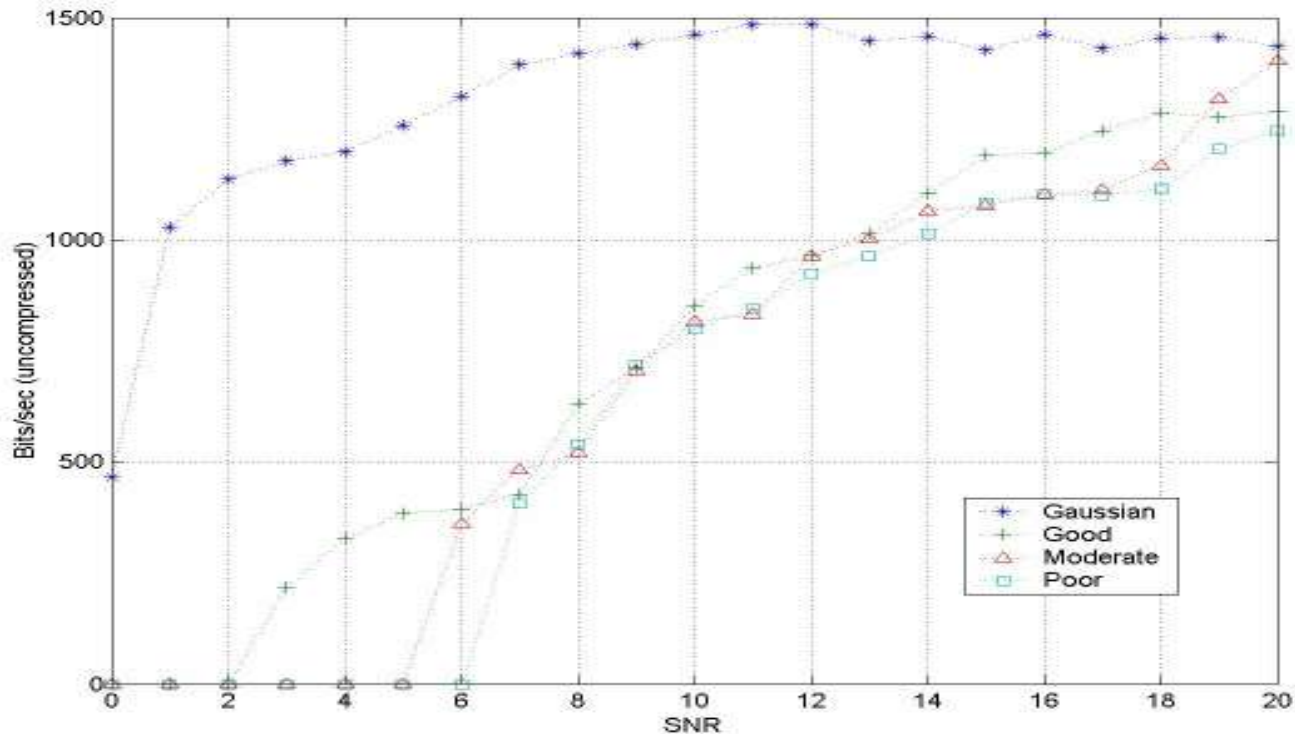
RNR: Peer must wait



# HF Modem

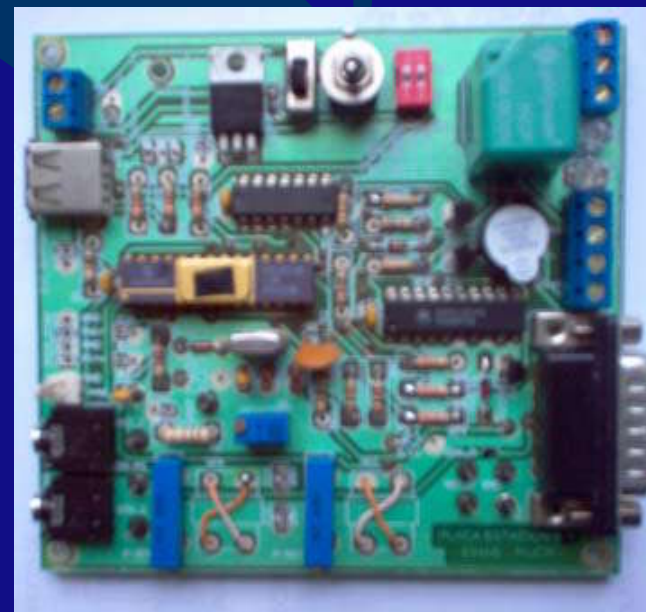
## Link performance (NewQPSK + AX25)

- SNR vs Uncompressed speed

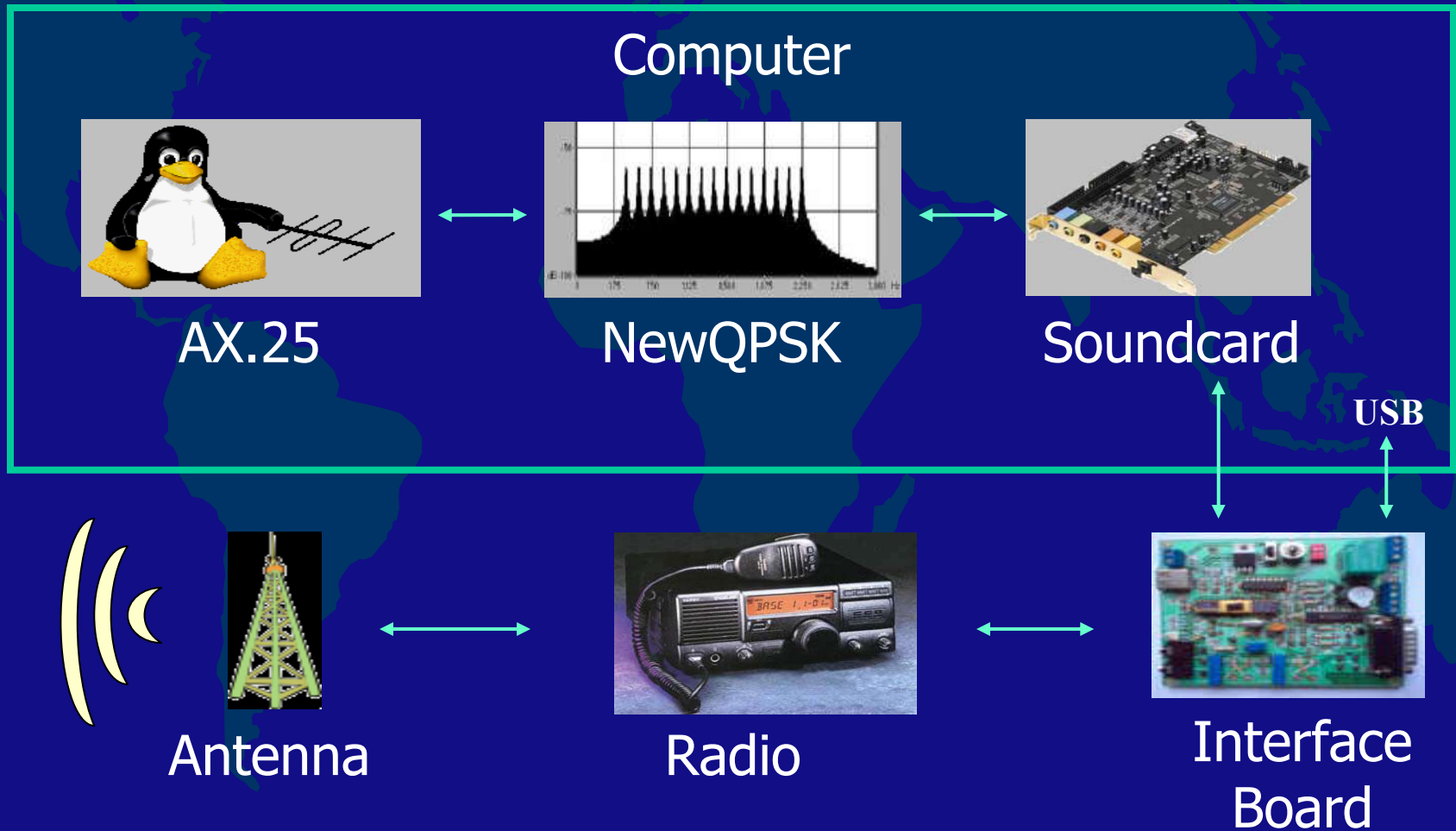


# Board interface

- **Interfaces between computer and radio**
  - PTT (Push-to-talk)
  - Ignition
  - Channel selection
- **Monitoring services:**
  - Battery level
  - Battery charge
  - Radio temperature (controls a cooler)
  - Measures SWR (Standing-Wave-Ratio)



# HF Modem Hardware Scheme



# Services provided

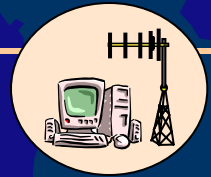
## Email

- **Electronic-mail is the most used data communication in EHAS networks**
- **Transmission requirements:**
  - **Resume broken transfers** -> **UUCP**
  - **Data compression** -> **BSMTP**
- **MTA (Message Transfer Agent)**
  - **Simple and secure** -> **POSTFIX**



# Services provided

## Email



### Health Post

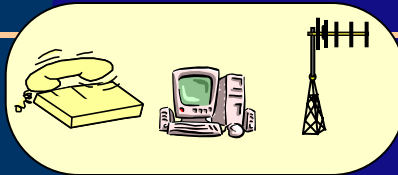
**E-Mail Client**

**Postfix**

**BSMTP**

**UUCP**

**EHAS Modem**



### Health Centre

**Postfix**

**BSMTP**

**UUCP**

**EHAS Modem**

**Internet**

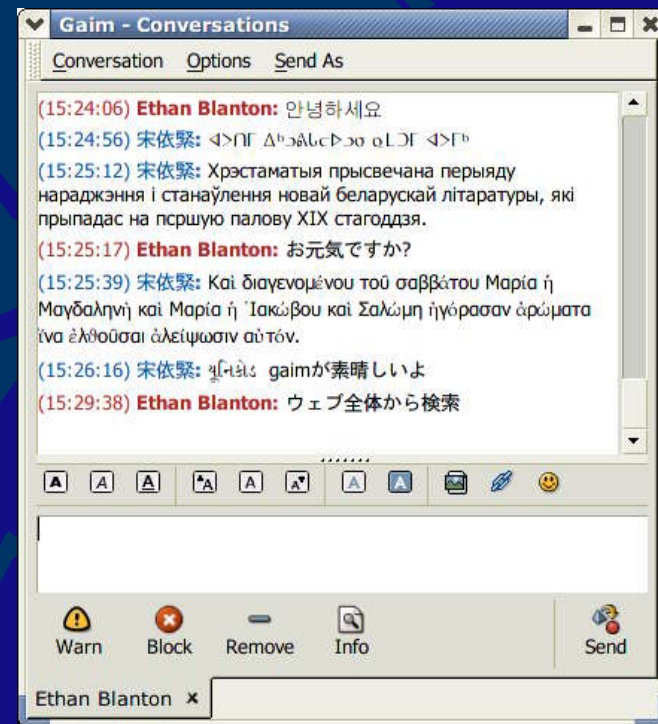


# Services provided

## Proxy web



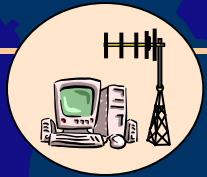
Web browsing



Chat

# Services provided

## Proxy web



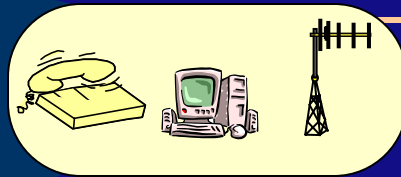
**Health Post**

**App using  
proxy web**

**TCP  
Tunnel**

**TCP-AX25  
Bridge**

**EHAS  
Modem**



**Health Centre**

**Internet**

**TCP  
Tunnel**

**TCP-AX25  
Bridge**

**EHAS  
Modem**



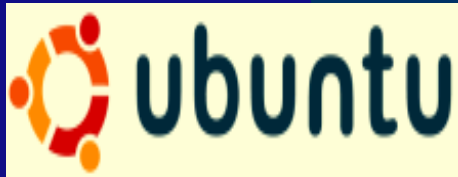
# Linux installation



[metadistros.hispalinux.es](http://metadistros.hispalinux.es)

## Metadistro/Ubuntu

- GNU/Debian based
- Hardware autodetection
- Live CD (with HD installation)
- Installation CD (only Ubuntu)
- Gnome Desktop
- Installed software: Gimp, OpenOffice, Mozilla Browser/E-mail client



[www.ubuntulinux.org](http://www.ubuntulinux.org)



# Pilot Projects

Currently pilot projects in Peru, Colombia and Cuba



# Pilot Projects



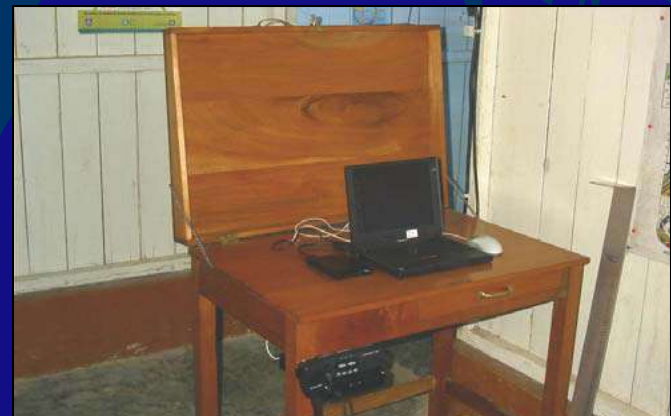
**Laptop**



**Dot matrix printer**



**Radio and modem**



**Work table**



# Other EHAS interests

## WiFi

- **Speed: 1 to 11 Mbps.**
- **Originally designed for indoor use.**
- **Reach up to 20 Km.**
- **Voice, internet and video communication with Linux.**
- **EHAS is currently working on a solar router.**



# EHAS Foundation: Rural Telemedicine in Latin America countries



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***Thanks for your attention***

**E-mail contact: [arnau@ehas.org](mailto:arnau@ehas.org)**

