Voice over wireless ad hoc networks

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Motivations for alternative voice networks

- **A Brazilian market survey** [1]
  - Currently, 11.685 locations have no fixed telephony services, which corresponds to 1.75 Mi potential subscribers.
  - At places with no fixed telephony, about 37% adopt an alternative telecommunication system and the most used is the cellular system (69%).
  - Due to pricing and bad coverage, about 74% claimed that would change to another telecommunication system that provides lower cost voice services.
  - About 82% of the non-attended users stated that they need a communication system and their main interest is for voice services.
  - People would accept to spend from US$80.00 up to US$400.00 with equipments and they plan to spend monthly rates ranging from US$20.00 to US$36.00 with the services.

[1] Source: market survey performed by CPqD.

Motivations for alternative voice networks

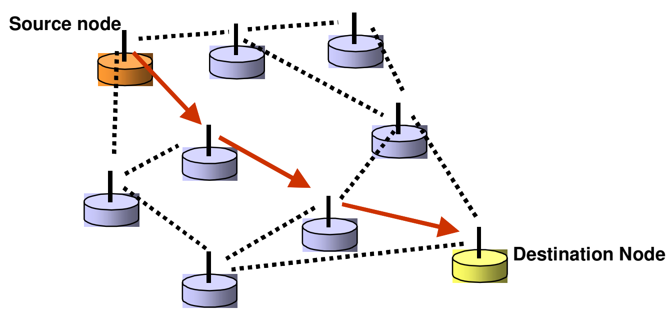
- **Synthesis of Brazilian scenario**
  - Despite the significant progress in mobile communications and data transmission areas, Brazil still has people who do not have access to any communication system
  - This part of Brazilian population lives
    - In small towns or rural areas, where the deployment and maintenance costs of telecommunications networks are high
    - In urban areas, but is not economically active
  - The current business models adopted by Brazilian service providers still impose constraints for citizens from layers C, D and E

The RAHSF Project

- **Goals**
  - **Development of wireless access technology for voice and low data rate services, based on lower cost infrastructure**
  - **Searching for alternative service models that enable the inclusion of non-attended Brazilian communities**

The RAHSF Project

- **Wireless ad hoc networks**
  - An alternative to reduce the infrastructure cost, since the subscriber stations work as wireless routers, thus increasing effective coverage with no additional base stations



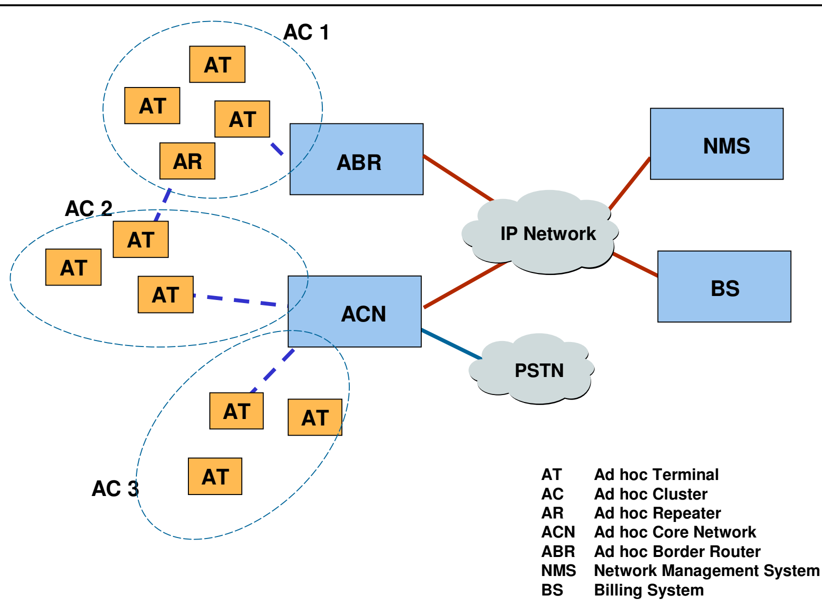
The RAHSF Project

- **System requirements**
  - It shall provide voice and data services
  - For data services, transmission rate shall be greater than 64 kbit/s
  - It shall adopt low cost subscriber terminals
  - It shall provide connection to PSTN and IP networks
  - It shall be based on packet transmission
  - It shall be able to identify system faults and to provide external visualization of them
  - It shall be possible to collect data for quality of service evaluation
  - It shall operate at frequency bands in compliance with Brazilian spectrum regulation
  - It shall operate in multihop scenarios.

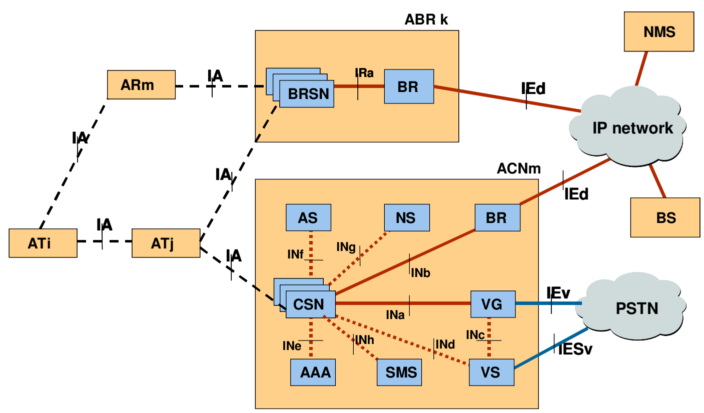
The RAHSF Project

- **Operation frequency**
  - Considering the spectrum regulation at Brazil, the following frequency bands are considered
    - 400 MHz band: sub-bands within the 411-470 MHz range
    - 900 MHz band: sub-bands within the 902-953 MHz range
    - 2400 MHz band: 2400-2483,5 MHz
    - 5000 MHz band: 5275-5780 MHz
  - The 400 MHz band is more appropriated for rural areas, because the transmission power limit is high (10 Watts), thus resulting in higher covering radius
  - For operation in urban environments the 900 MHz, 2400 MHz and 5000 MHz bands are more appropriate

Network Topology



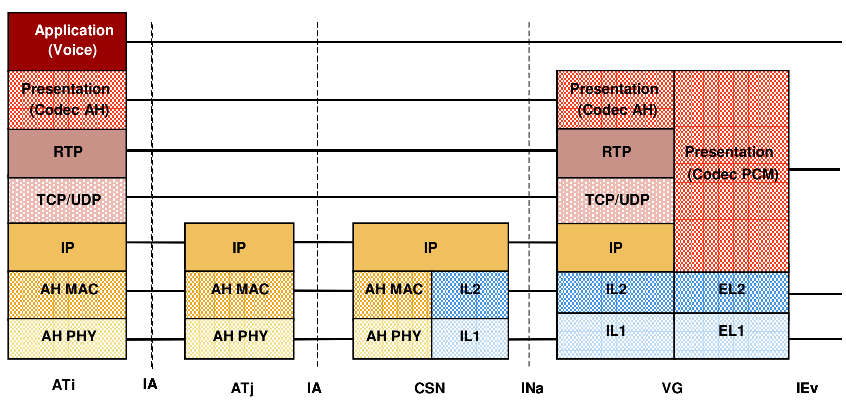
Network Architecture



AS	Address Server
NS	Name Server
CSN	Core Service Node
AAA	Authentication, Authorization, Accounting
SMS	Short Message Server
VG	Voice Gateway
VS	Voice Server
BR	Border Router
BRSN	Border Router Service Node

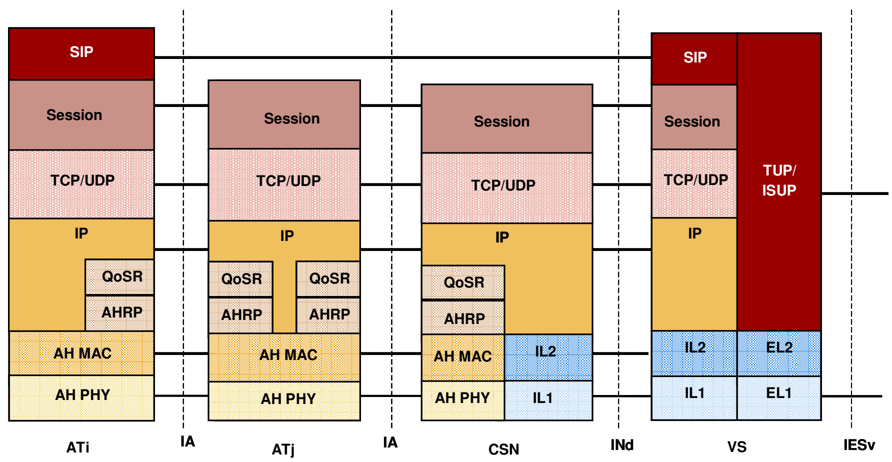
Protocol Architecture

- **Transmission Plane**



Protocol Architecture

- **Signaling Plane**



Wireless ad hoc networks

- **Classic solutions for wireless ad hoc networks**
  - Routing
    - Destination-Sequenced Distance Vector (DSDV)
    - Dynamic Source Routing (DSR)
    - Ad hoc On Demand Distance Vector (AODV)
    - Optimized Link State Routing (OLSR)
  - Wireless Medium Access Control
    - TDMA
    - CDMA
    - CSMA/CA (IEEE 802.11)

Not designed to support real time services!

Voice over wireless ad hoc networks

- **Most relevant requirement**

  Quality of Service

- **Challenges for achieving QoS on wireless ad hoc networks**
  - Topology dynamics
  - Unreliability of network state information
  - Absence of central coordination
  - Radio channel variability
  - Connectivity problems
  - Constrained resources

Voice over wireless ad hoc networks

- **Current solutions for QoS support in ad hoc networks**
  - **QoS Routing**: includes QoS metrics (eg., bandwidth, delay) in route discovery and maintenance algorithms.
    - QOLSR
    - QoS-AODV
    - TDR
    - AQOR
  - **QoS Frameworks**: consists of architectures for handling specific QoS management functionalities, such as admission control, bandwidth reservation and others.
    - INORA
    - SWAN
    - INSIGNIA

Can be integrated with multiple routing protocols → **Flexibility!**

Voice over wireless ad hoc networks

- **INSIGNIA - In-band Signaling for QoS in Ad-Hoc mobile networks**
  - Similar to IntServ QoS Model
  - Provides per-flow QoS by inserting signaling messages in data packets (IP Option field).
  - Defines two traffic classes: Real Time and Best Effort.
  - Adopts a soft-state mechanism to perform bandwidth reservation.
  - Supports distributed admission control.
  - Packet forwarding is handled via a scheduling mechanism (eg., WFQ).

Voice over wireless ad hoc networks

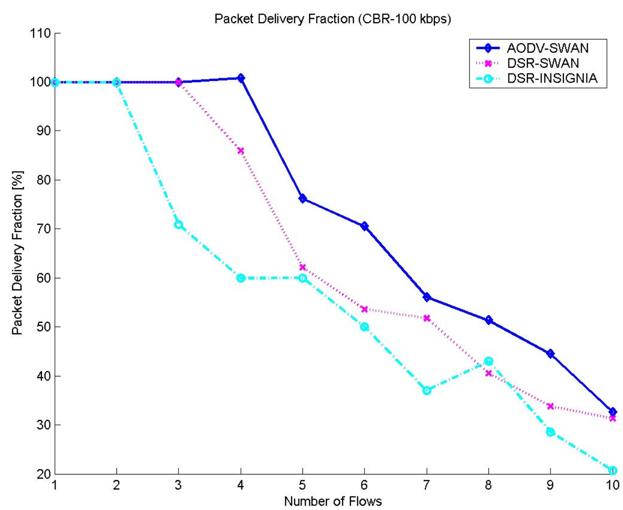
- **SWAN - Stateless Wireless Ad Hoc Networks**
  - Defines two traffic classes: Real Time and Best Effort
  - Adopts a stateless QoS management scheme, which eliminates the overhead associated to resource deallocation procedures
  - Residual bandwidth is locally calculated, based on MAC delay estimates
  - The transmission rate for the Best Effort traffic is locally estimated and adjusted to acommodate the bandwidth required by the Real Time traffic
  - Supports source-based admission control and distributed congestion control for the Real Time traffic

Voice over wireless ad hoc networks

- **Performance evaluation via simulations**
  - Simulation tool: NS-2
  - Scenario: congestion and static topology
  - Operation frequency: 400 MHz
  - Propagation model: Two-ray ground
  - Coverage radius: 10 Km
  - Transmission power: 20 dBm
  - Traffic rate: 64 Kbps (G.711) + 20% overhead = 100 Kbps
  - Transmission rate (PHY): 11 Mbps
  - Routing Protocols: DSR and AODV
  - QoS Frameworks: SWAN and INSIGNIA

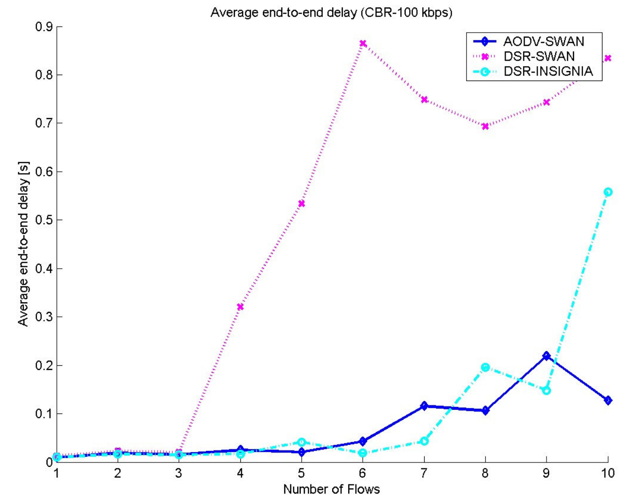
Simulation Results

- **Packet Delivery Fraction**



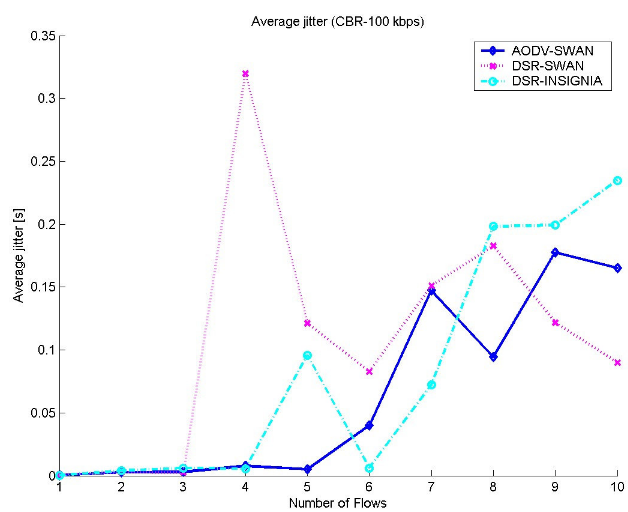
Simulation Results

- **Average end-to-end delay**



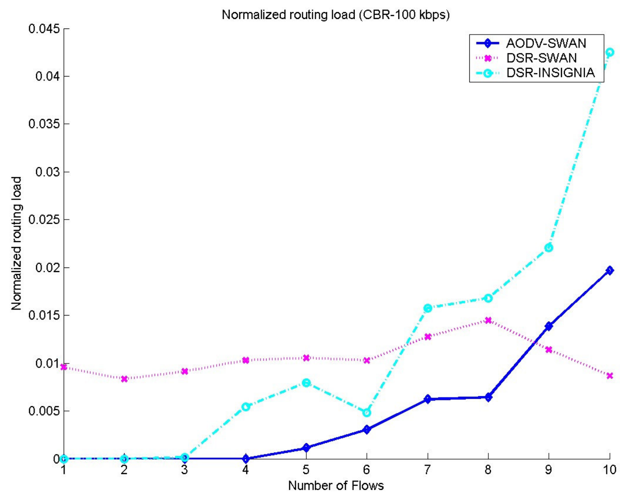
Simulation Results

- **Average jitter**



Simulation Results

- **Normalized routing load**



Future Perspectives

- **CPqD aims at developing a real world wireless ad hoc network to support voice services for non-attended communities.**
- **A preliminary prototype of the whole system is planned to be available in 2005.**
- **Several technological challenges are under investigation, including QoS, routing and medium access control techniques for wireless ad hoc networks**
- **Field trials are scheduled to the second semester of 2006.**
- **CPqD is already trying to establish industrial partnerships to produce the equipments developed in the RHASF Project.**

Thank you!

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