



# Networking Tonga from the Ground Up and the Sky Down

Dewayne Hendricks  
Dandin Group



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Once upon a time.....



# Magic and Technology

- Clarke's Third Law

“Any sufficiently advanced technology is indistinguishable from magic”



# Agenda

- Personal Log
- Regulatory Precursors
- Kingdom of Tonga Project
- Technology Roadmap
- What's Next?
- Questions



# Personal Log

- Ham radio operator at 12
- User of ARPANET in '74
- Wireless Internet startup in '90
- Many wireless projects in developing countries
- Member of team that brought Net to Mongolia



# Regulatory Precursors

- SS NOI in '81
- Introduced notion of wideband technologies (aka spread spectrum)
- Introduced 'spectrum overlay' as part of spectrum management toolkit
- NPRM in '84
- R&O in '85



# Unlicensed Radio History

- FCC Part 15 in 1985
- WLAN products
- WMAN products
- Data-PCS at 1.9 GHz in '94
- Data-PCS at 2.9 GHz in '96
- U-NII Band in '97



# Next Step?

- Requirement for more bandwidth
- Need to deploy real wideband technologies
- Establish Bay Area Testbed
- Find country for next testbed





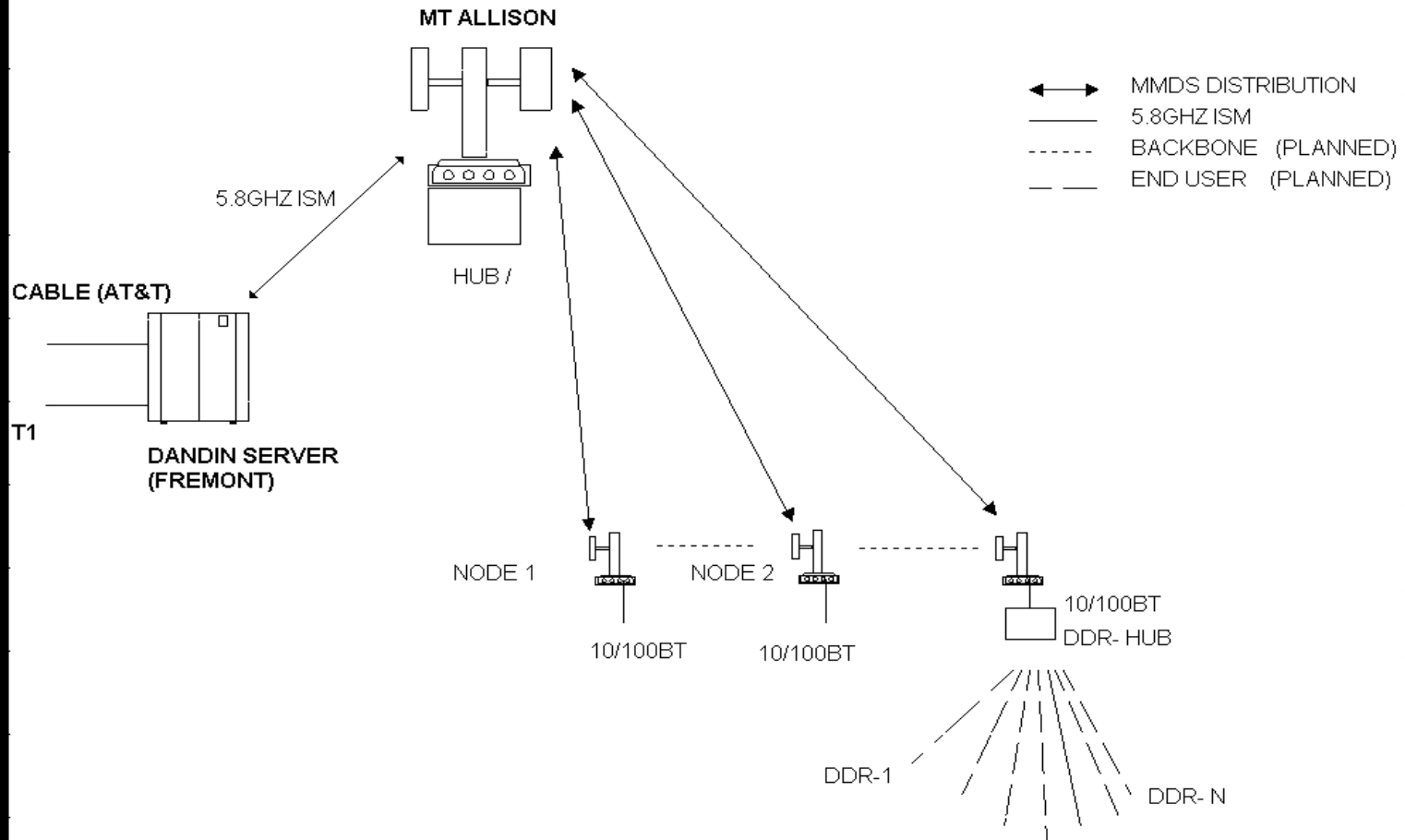
# SF Bay Testbed Details

- Started in Fall '96
- Covered 35 mi area in south bay
- Delivered from ISDN to 30 Mbps bandwidth
- Used both licensed and unlicensed equipment (Part 15 and 97)



# SF Bay Testbed

## DANDIN INTEGRATED WIRELESS NETWORK BAY AREA SYSTEM



DANDIN GROUP COMPANY CONFIDENTIAL

dandingroup



# New Problems

- Internet Appliances
- UWB = More Bandwidth!!!
  - Spectrum Overlay required
- Smart Radios
  - Software Defined Radios
- Convergence
  - Mobility vs Fixed



# Regulatory Recap

- Regulatory issues are the biggest problem in the way of a paradigm shift for wireless!
- More technology available than we know what to do with!
- Need to find a place where wireless regulatory issues are absent!!

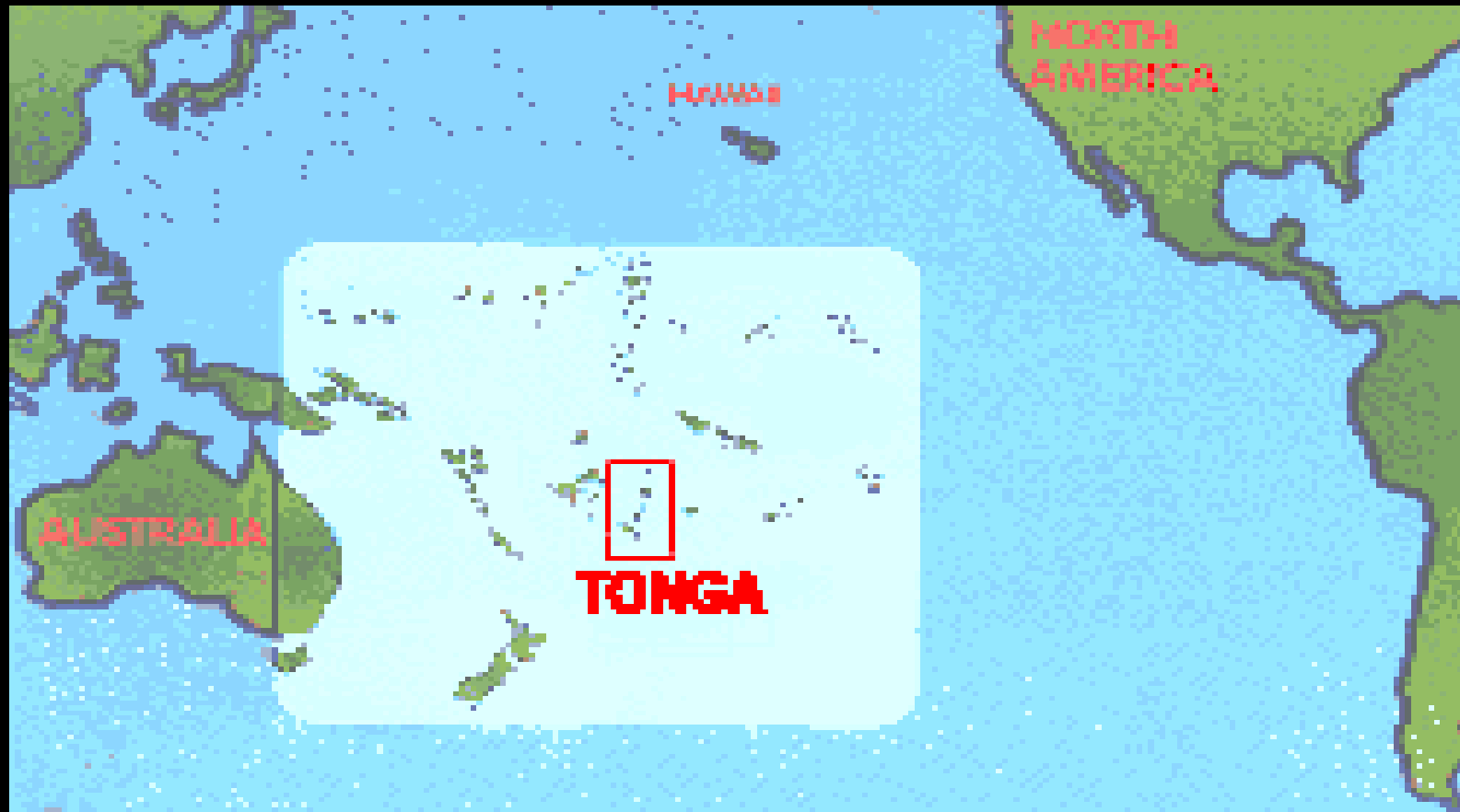


# Kingdom of Tonga Project

- Island group in the South Pacific
- About 171 islands, 70 inhabited
- 100K people in Tonga, about the same number outside Tonga
- Agricultural exports main source of income
- One of the last true monarchies

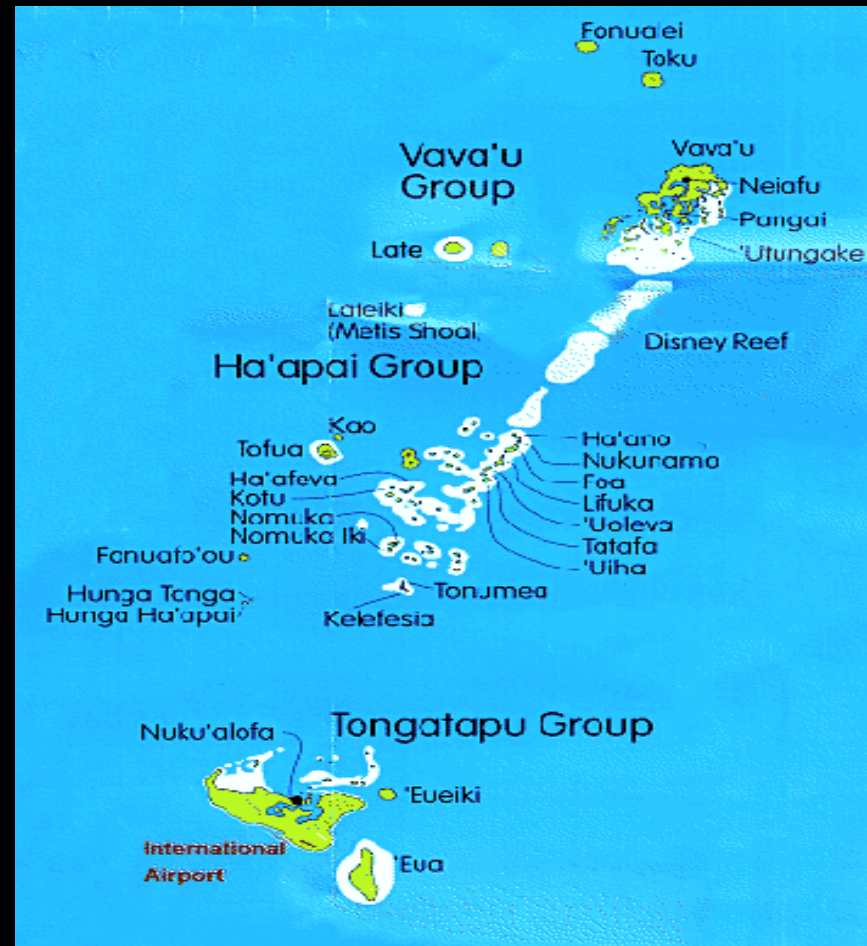


# Kingdom of Tonga





# Islands of Tonga





# Tongatapu







# The Task

- Business project of the Crown Prince
- Move country from wired to totally wireless infrastructure
- Two Phases
  - International (provide telephony and Internet access)
  - Domestic (provide multiple services w/IP)
- No wireless regulatory issues!



# Basic Statistics

- 11,000 Households
- 6500 phone customers
- 8 yr. waiting list to get a phone
- Cable & Wireless handles international
- Tonga Telecom handles domestic



# New Services

- **Wireless Multiservices IP Network**
  - Scalable, fully meshed network
- **Use of wideband wireless devices**
  - Spread Spectrum and Ultra-Wideband
- **New two-way VSAT technologies**
  - Ku band
- **Support for new Internet appliances**
  - New PDA's (such as Palm Pilot)
  - Sony's Playstation II
- **Goal of CPE cost of about \$450**



# Services to be offered

- VoIP for telephony
- Internet data
- Video (two MPEG-2 streams)
- Deliver 30 Mbps symmetric to each home
- Wireless Mobility



# Tonga Network Details

- Three level hierarchy
- Mesh routing at each level
- Every device in network routes
- Residential Gateway unit at each home
  - Provides support for mobility
  - Gateway for multimedia services





# Star Trek as a Model

- Well known cultural icon
- \$2 Billion per year industry
- Great Broadband Data model
  - Communicator
  - Holodeck
  - Transporter
  - Tricorder
- How do we get there from today???



# Amateur Radio Efforts

- Outgrowth of earlier efforts
  - ARPANET, SATNET, PRNET
  - SURAN Project
  - ALOHA - Univ.. of Hawaii
- First packet radio networks in '80
- Full-scale wide-area deployments by '85





# AX.25 Path

- Spin on X.25
- Terminal Node Controller (TNC)
- TAPR Work
  - TNC-1 (first generation)
  - TNC-2 (second generation, still used today)
- Part 97 Rule changes in '85 made packet radio networks possible



# AX.25 Today

- PBBS Network in place
- Worldwide deployment
  - VHF/UHF used for local links
  - HF for long distance links
- Low-cost global wireless Internet



## IP Path

- Started in '85
- Based on KA9Q IP Package
  - First cross platform PC based IP development effort
- Provided base for new hardware
  - low-cost 56 Kbps RF modem available in '86



# IP Today

- Global wireless packet Internet exists
- TCP/IP based
  - VHF/UHF for local
  - AX.25 over IP tunneling
  - RSPF routing
- Low cost hardware to 3 Mbps available



# Outcomes from ARS Efforts

- Low-cost packet radio hardware
- First 'open hardware' model
- Early 'open software' model
  - KA9Q Internet Protocol Package
- Scalable ad-hoc packet networks
- Framework for software defined radios



## Next Steps

- Continue to build network in Tonga
- Continue to deploy in US in tribal and underserved areas
- Find other 'regulatory havens'
- Continue to push the wireless technology forward through open systems approach



# AN-MSI Project

- \$6M NSF and EDUCAUSE 4 yr effort
- Deploy pilot projects in Tribal Lands
- Use similar architecture and technologies as in Tonga
- Adapt to US regulatory environment
- Innovative use of two-way satellite and terrestrial wireless for low-cost solution



# Questions?