# Pushing Unlicensed Wireless to the Limit: Aspen to Antarctica and Burning Man to Bhutan

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Charybdis

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# Charybdis- introduction

- Not in academia
- Not exactly in industry
- Microscopic research organization (MRO)
- Our research feels far-fetched but is steeped in reality

- Dave Clark: “start small”
- Harvie Branscomb” “stay small”

- research interests: theatrical internet experience, interactive art, applications of wireless networks

# Unlicensed Wireless Ethernet - a definition

- 802.11b...ISM Band @ 2.4 GigaHertz
- Direct Sequence Spread Spectrum
- 11 Megabits maximum
- Low Cost:
  - Access Point ~ $500
  - PCMCIA Client ~ $100
- Range- at least 100 m; 10-30 km in excellent conditions
- Many vendors
- Industry standard- in some ways:
  - no standard software driver
  - all clients share common spreading code
- 3 non overlapping bands if using 11 Megabits

# 802.11b… what was it designed for?

- Single fixed point to single fixed point wireless ethernet,
  - wlan bridge between buildings
- Many fixed points wired together connecting to nearby wireless clients for wide area indoor coverage
  - factory or warehouse
- Single fixed point to nearby wireless clients
  - lan access point for in home or office mobility

# What do I think 802.11b is better used for?

- Installations in confined spaces with roving clients which need to be inexpensive and standardized
  - home lans
  - airports, internet cafes
  - hotels, campuses
  - uncontrolled areas where it is still possible to move to avoid interference
- Temporary internet installations
  - conferences
  - events
- Rural internet access where wire/fiber is not possible and density and interference activity is low
- The common thread: move the radio until it works

# Research environments

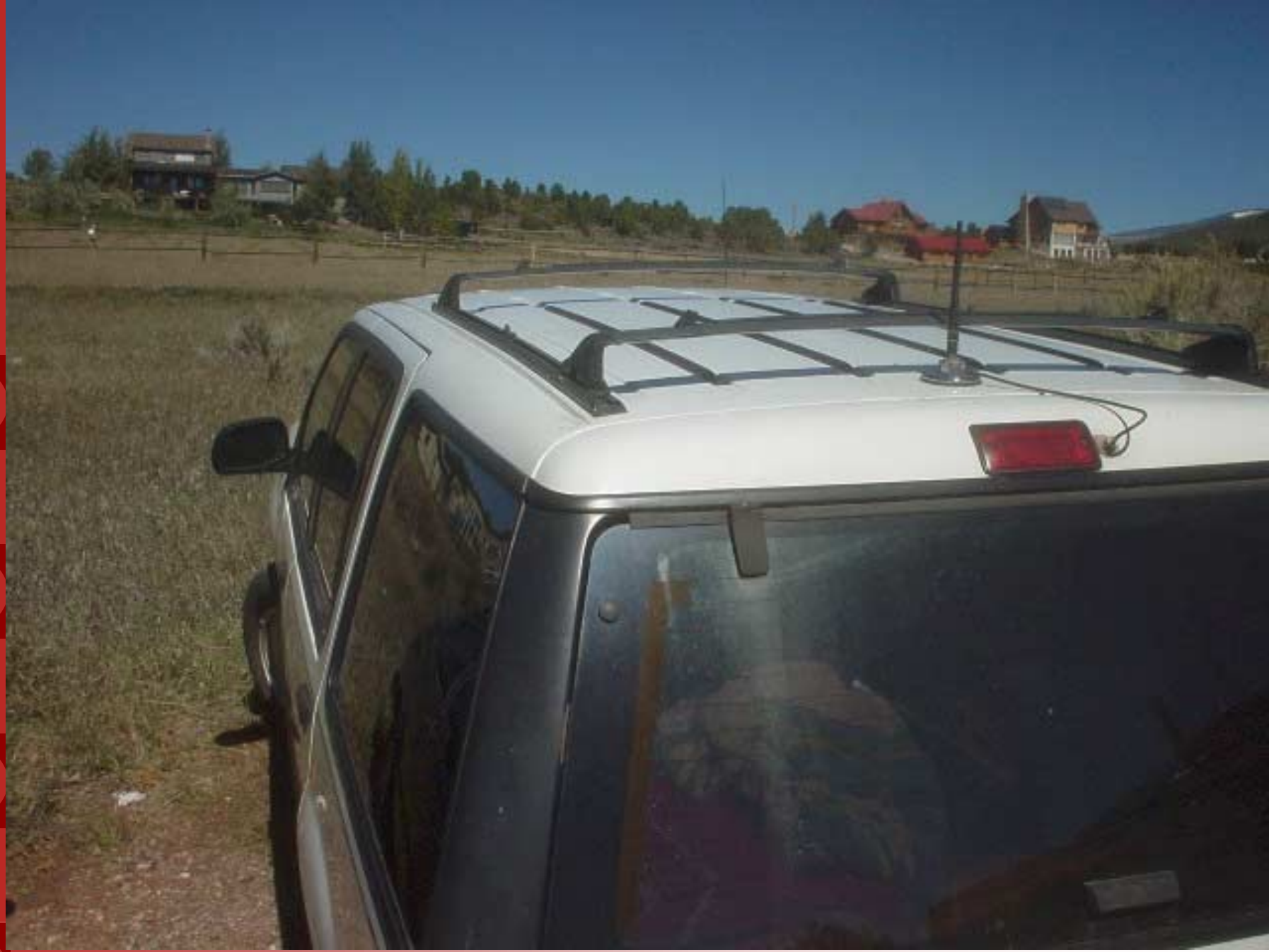
- Aspen- confined low density metropolitan area
  - surrounded by mountains, little existing RF activity
  - nearby areas extremely rural, no broadband available by wire
- Antarctica- extremely rural
  - in most cases no reasonable alternative approach
- Burning Man- week long event in absolutely flat desert
  - very temporary, unsuited to fixed wire application
  - strong interest in mobility
- Bhutan- 6,000 villages with no existing telephone service
  - similar to Aspen in geography
  - interested in fixed wireless for telephony
  - very urgent need for rapid deployment

# The Aspen Experiment

House with repeater near Aspen Colorado

# Rural Internet: Aspen,Colorado

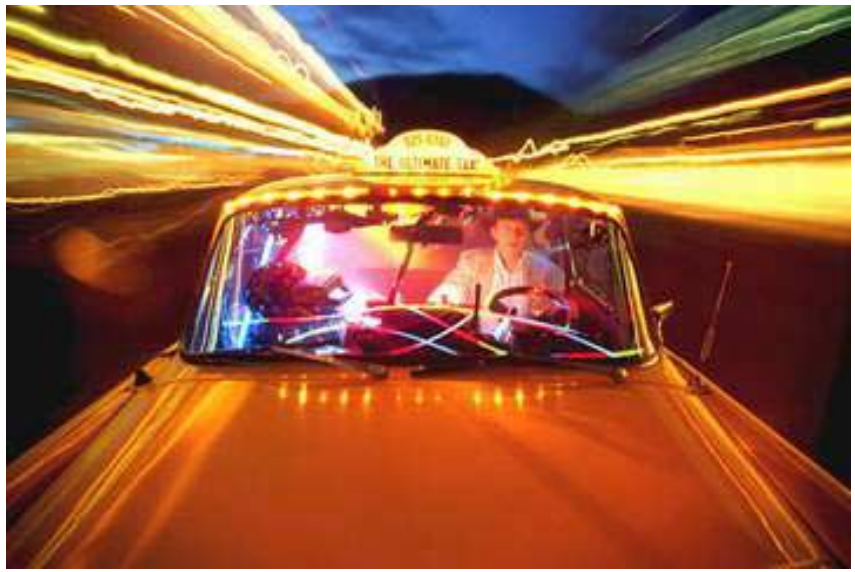
- 6 years using 802.11(b) for indoor/outdoor applications
- funded by Bill Joy, Sun Aspen Smallworks
- “Tree City, USA”
- about 15 repeaters around a 5 square mile metro area
- mixture of mobile and fixed use…
- mixture of indoor and outdoor…
- rejected the typical cellular topology
- numerous heavily wired houses (home networks)
- repeater in vehicle
- video conferences
- mobile web cams, Ultimate Taxi





Repeater on vehicle

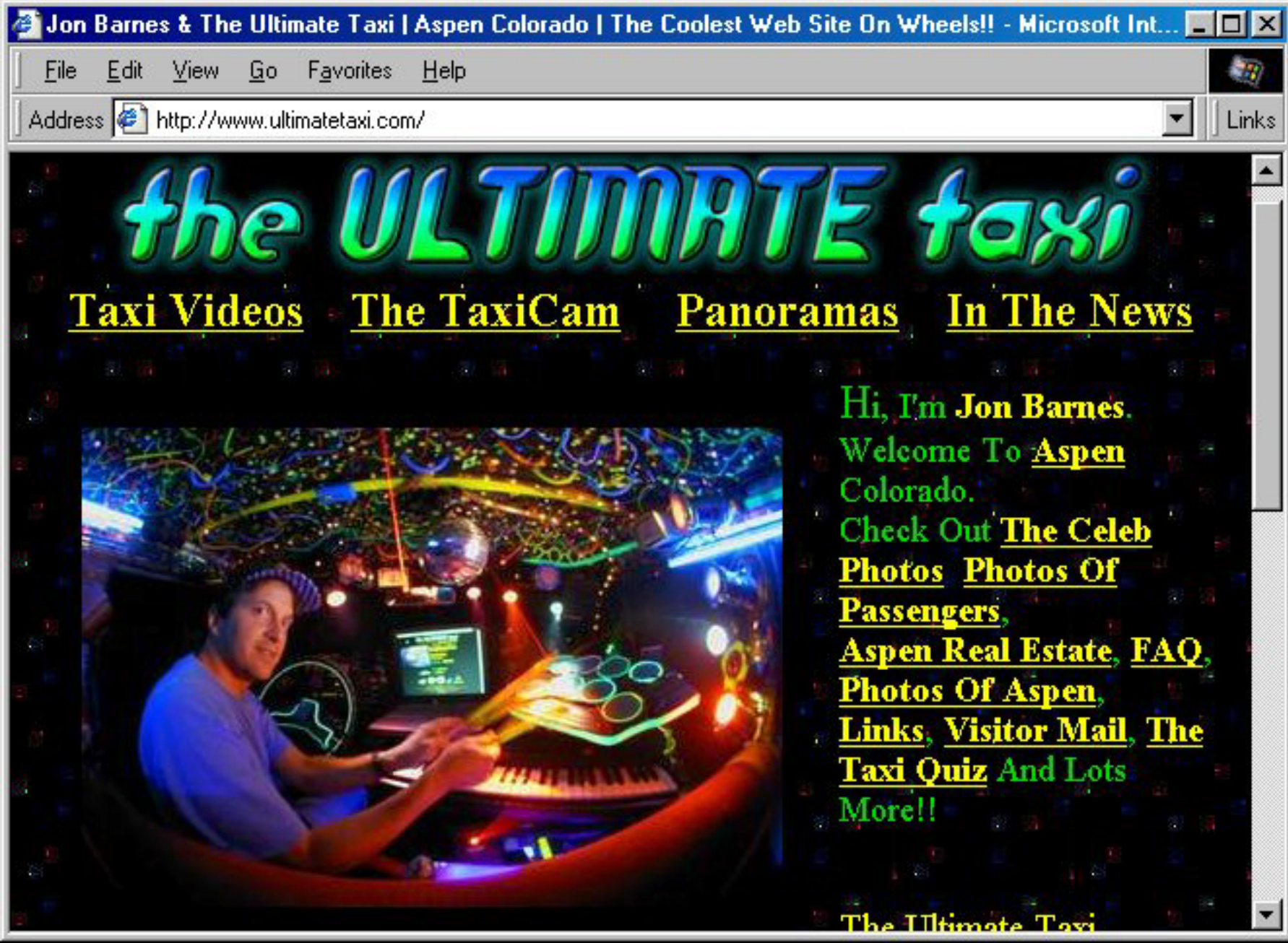
# Internet Mobility: The Ultimate Taxi



- Multiple video streams live from taxi entertain distant audiences
- Roams between wired access points and repeaters
- Vehicle adapts its route to current rf coverage conditions
- Car provides internet access by wire to driver's home when in garage
- http://www.ultimatetaxi.com

# Conclusions from Aspen experiences

- Many configurations are possible
- Big variation in what customers would actually like
- wide area coverage works fine except in trees, until interference
- Success invites oversupply and extra competition/interference
- voluntary cooperation is impossible
- Technology has nothing in its design to assist, except to become cheaper
- Cheaper would help coverage if you could afford the extra wired or well engineered backhaul paths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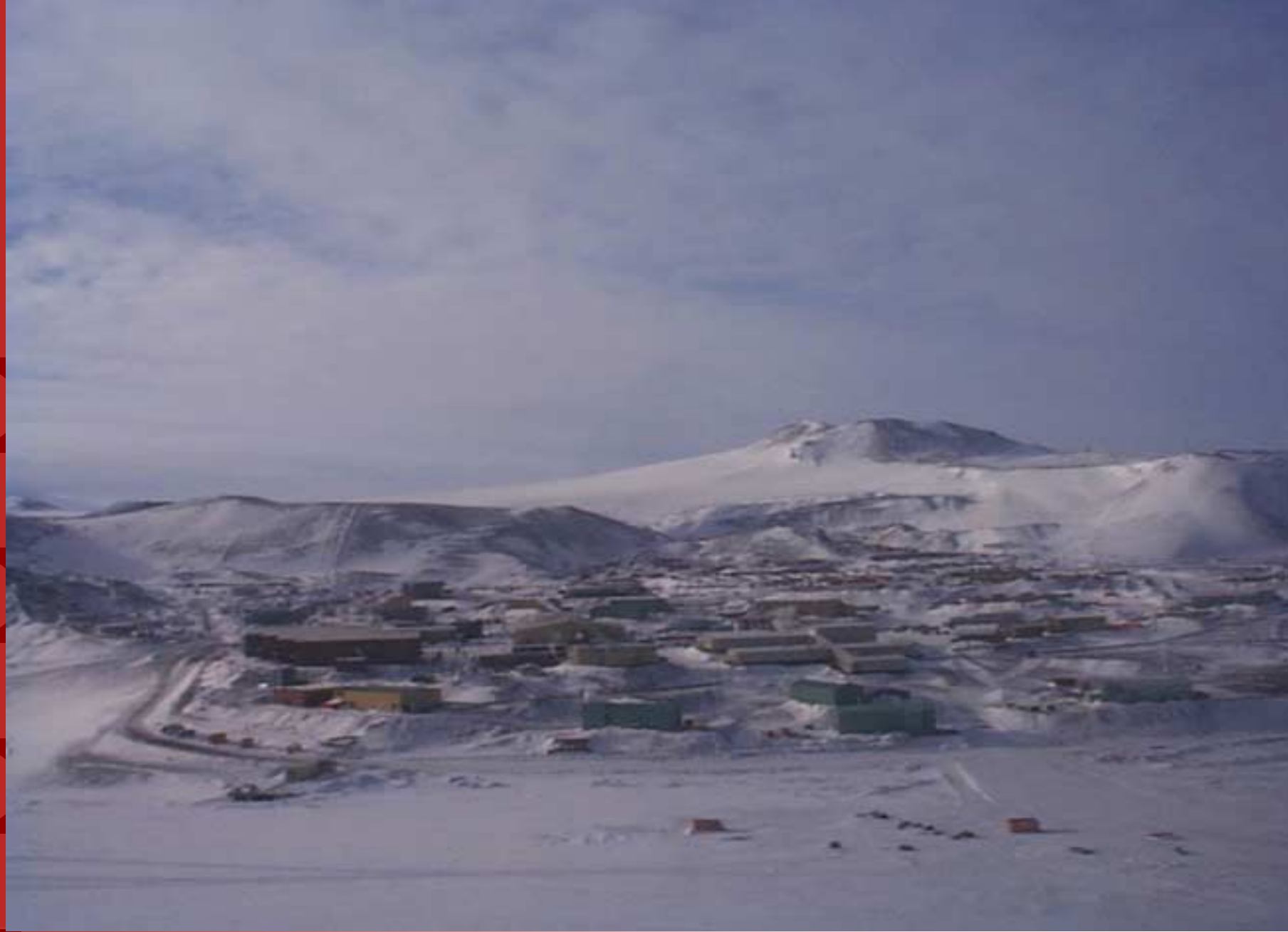
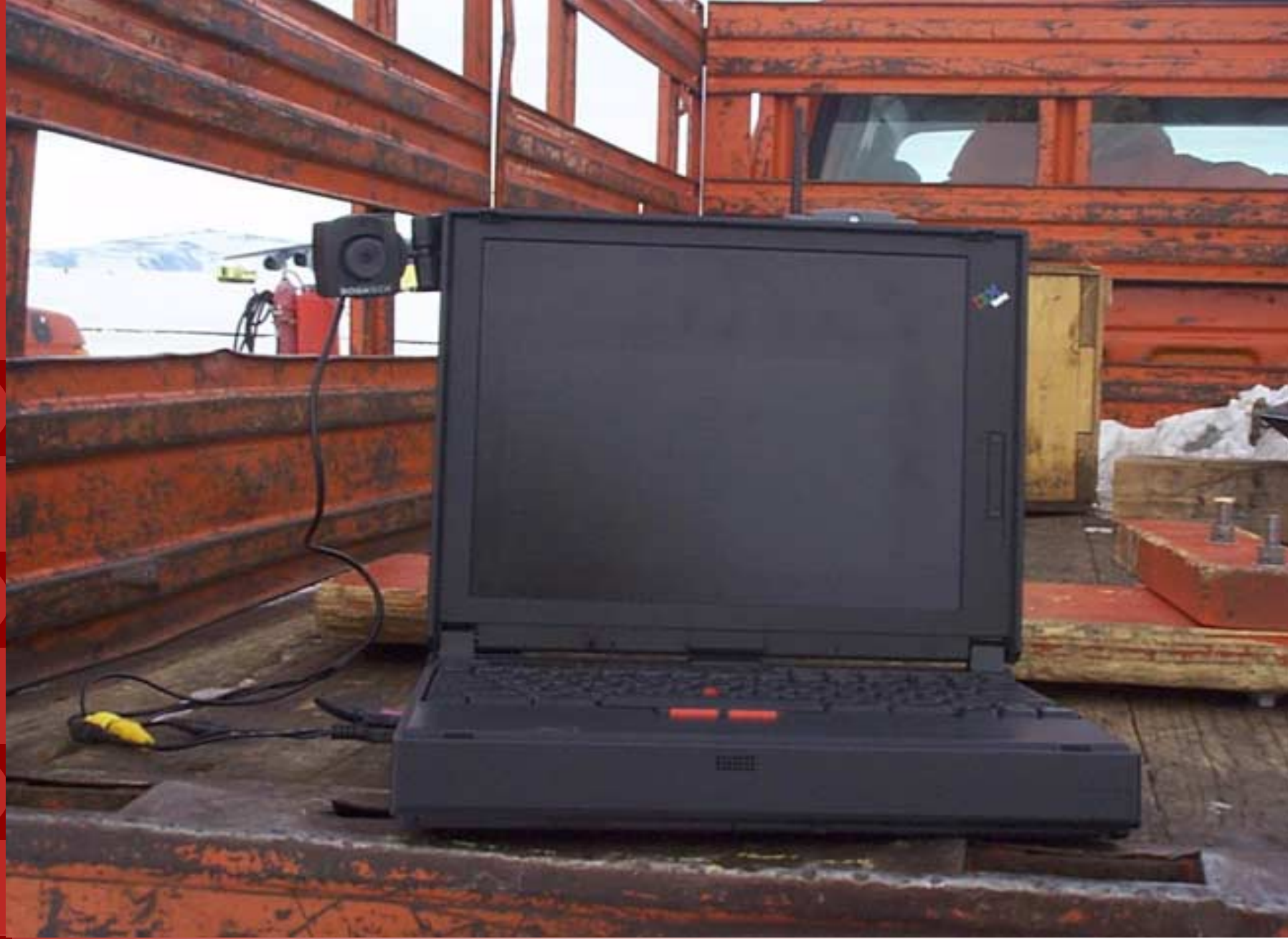
The Ultimate Taxi

# Distant Internet- McMurdo Station, Antarctica

- unofficial experiment in tightly controlled environment
- atmospheric conditions extreme
- no foliage
- sensitivity to interference with existing infrastructure



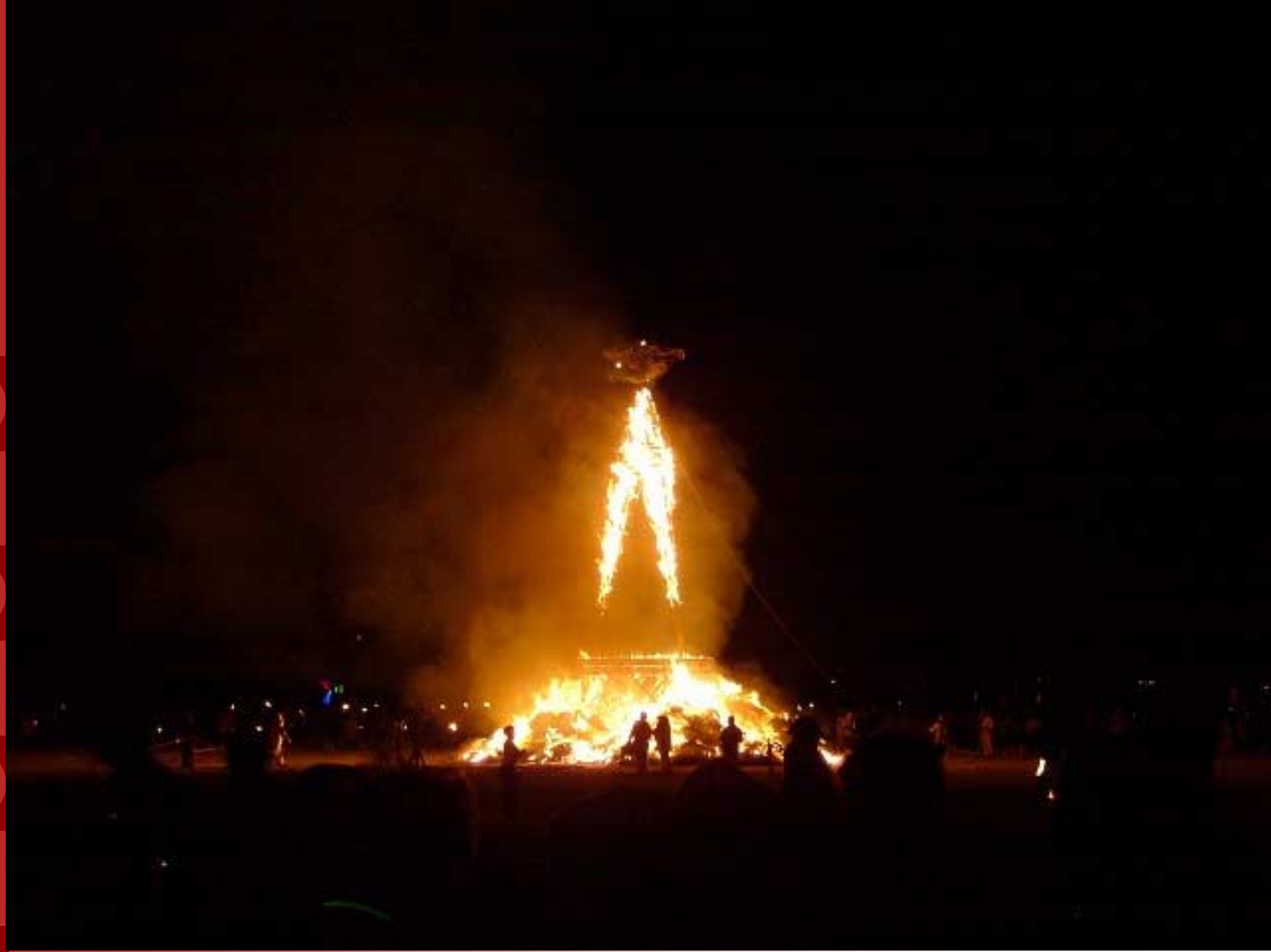
McMurdo Station, Antarctica



# Mobile Antarctic Web Cam

# Antarctic conclusions

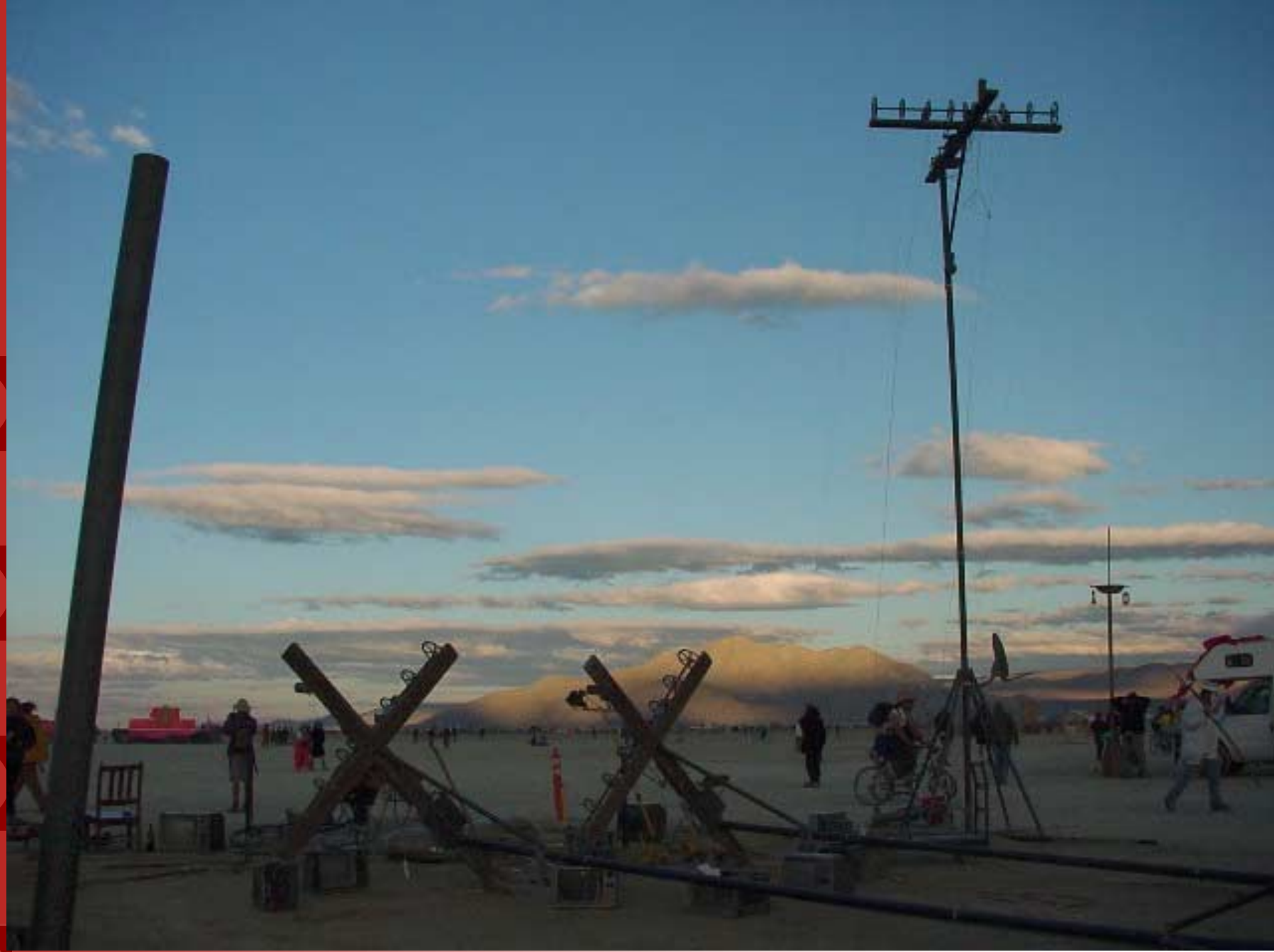
- Videoconference experiments for limited periods
- batteries and fingers do not work in low temperatures



The Burning Man

# Temporary Internet: Burning Man

- 25,000 people camp for a week in Black Rock Desert
- flat terrain, high winds, very dusty
- unusual planned usage:
  - video conference with Antarctica
  - audio streaming from vehicle
  - on-line stock puppets
  - uploading news stories and photos

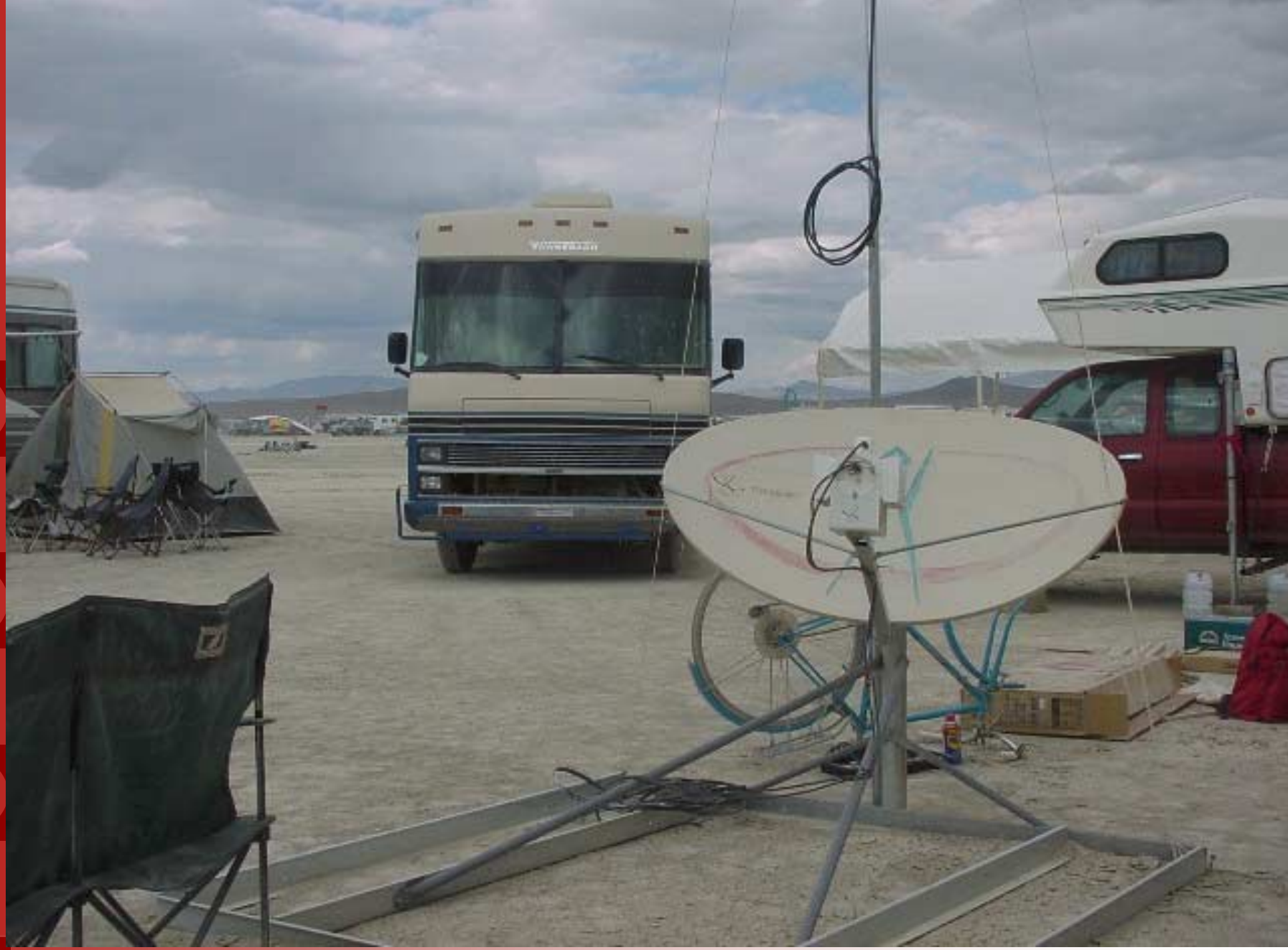




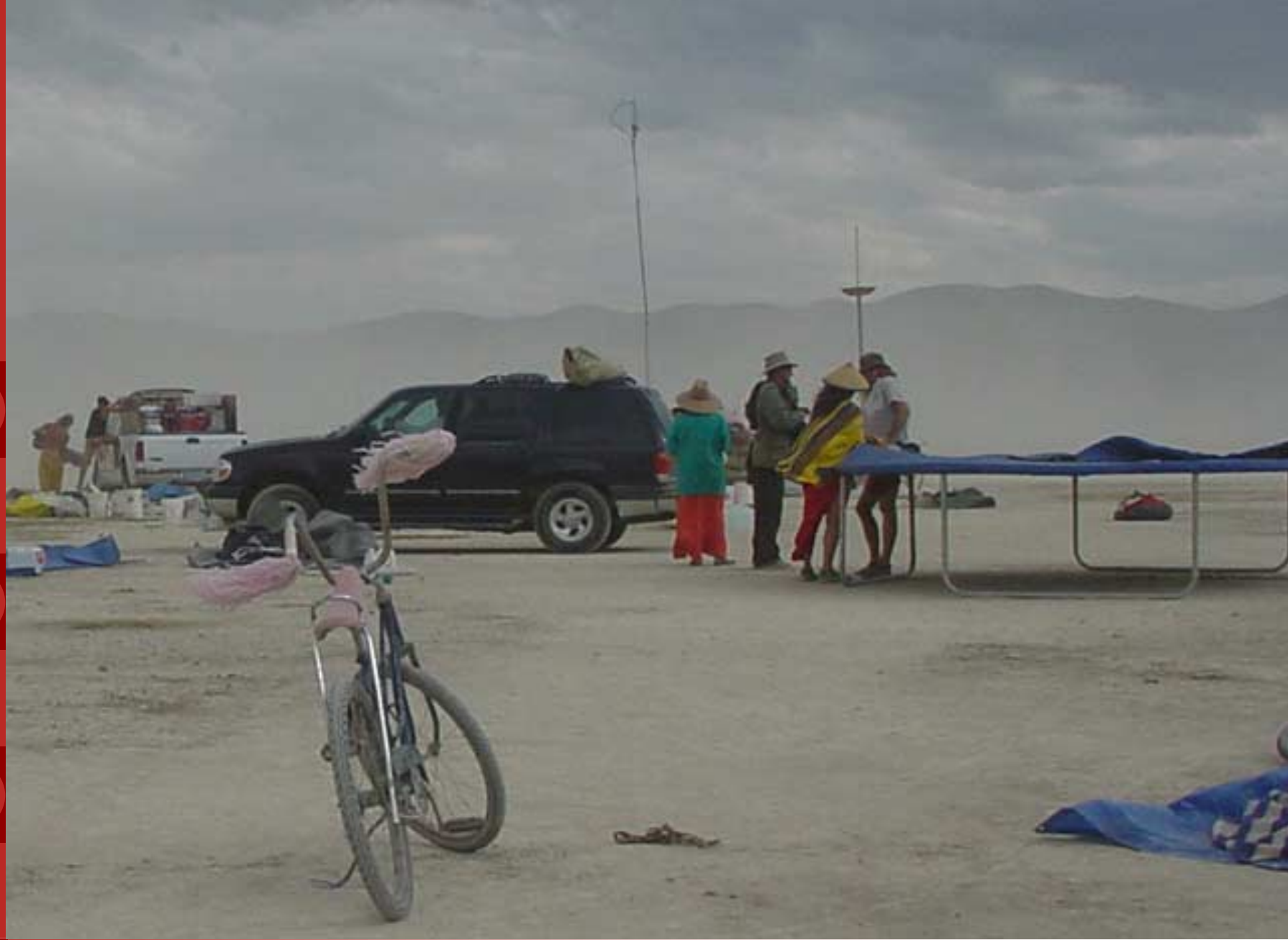
Internet Stock Market Puppets

# Burning Man: the solution

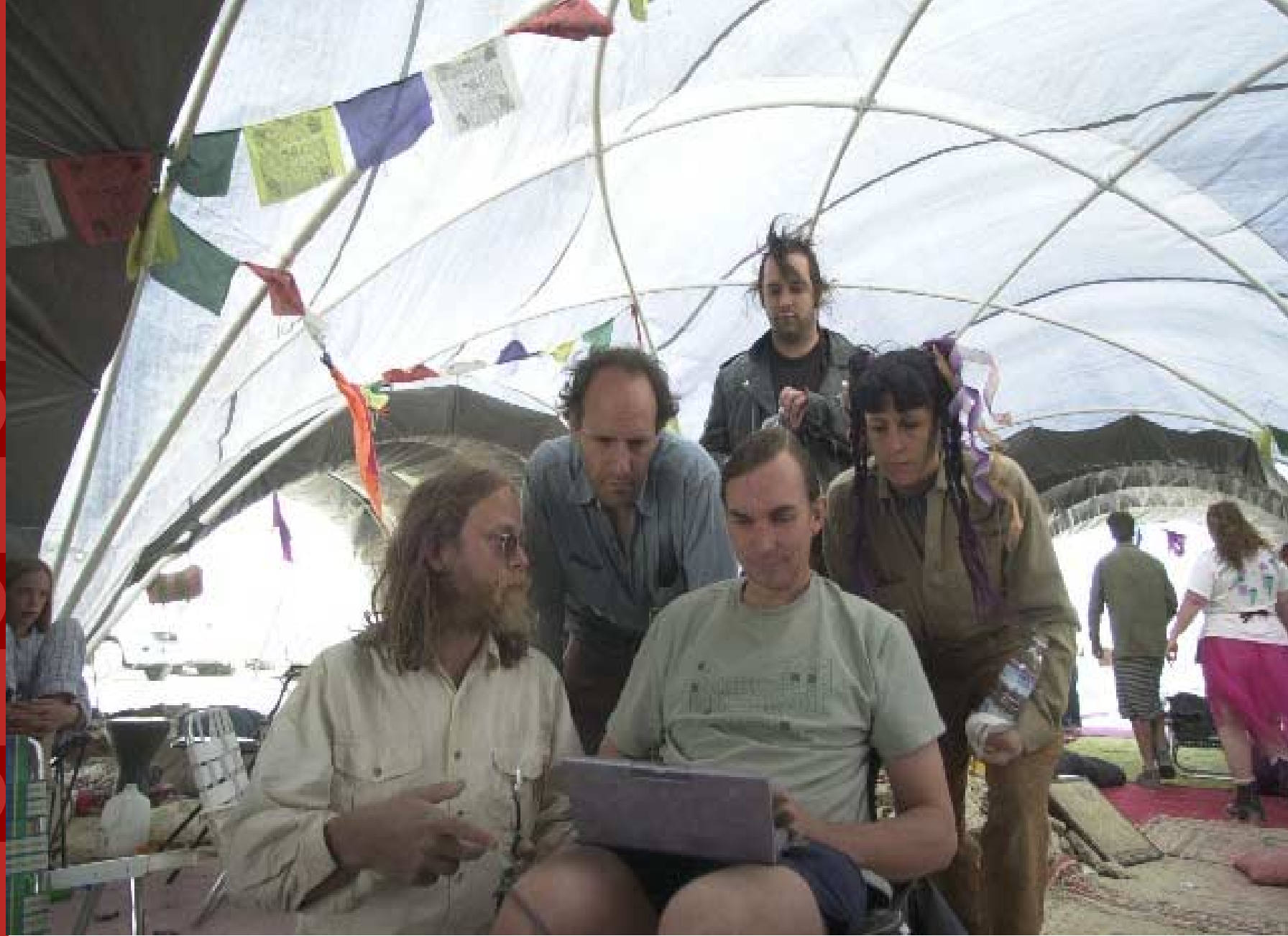
- Backhaul by satellite: 250 Kbits up and ~ 2Mbits down
- 5 cisco bridges, 4 used as repeaters
- mounted in Pelican cases for easy implementation
- Supported in part by John Gilmore (EFF)
- opportunities: laptops on bicycles,balloons etc.
- problems: winds vibrating the antennas
- fear of non-participation due to couch potato browsing
  - alternate wireless network planned… without internet access for philosophical reasons



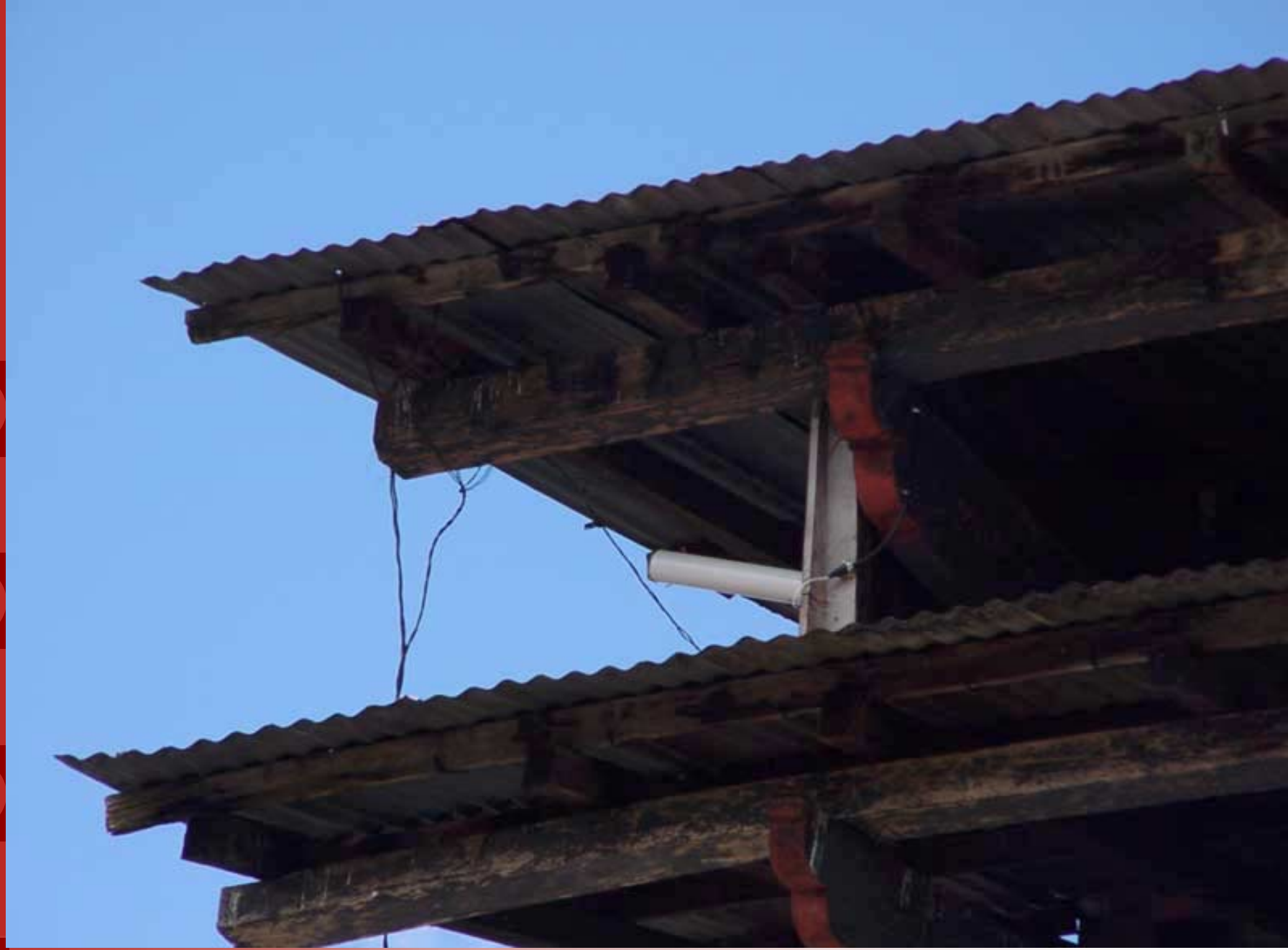
Tachyon Uplink at Burning Man



Repeater in background



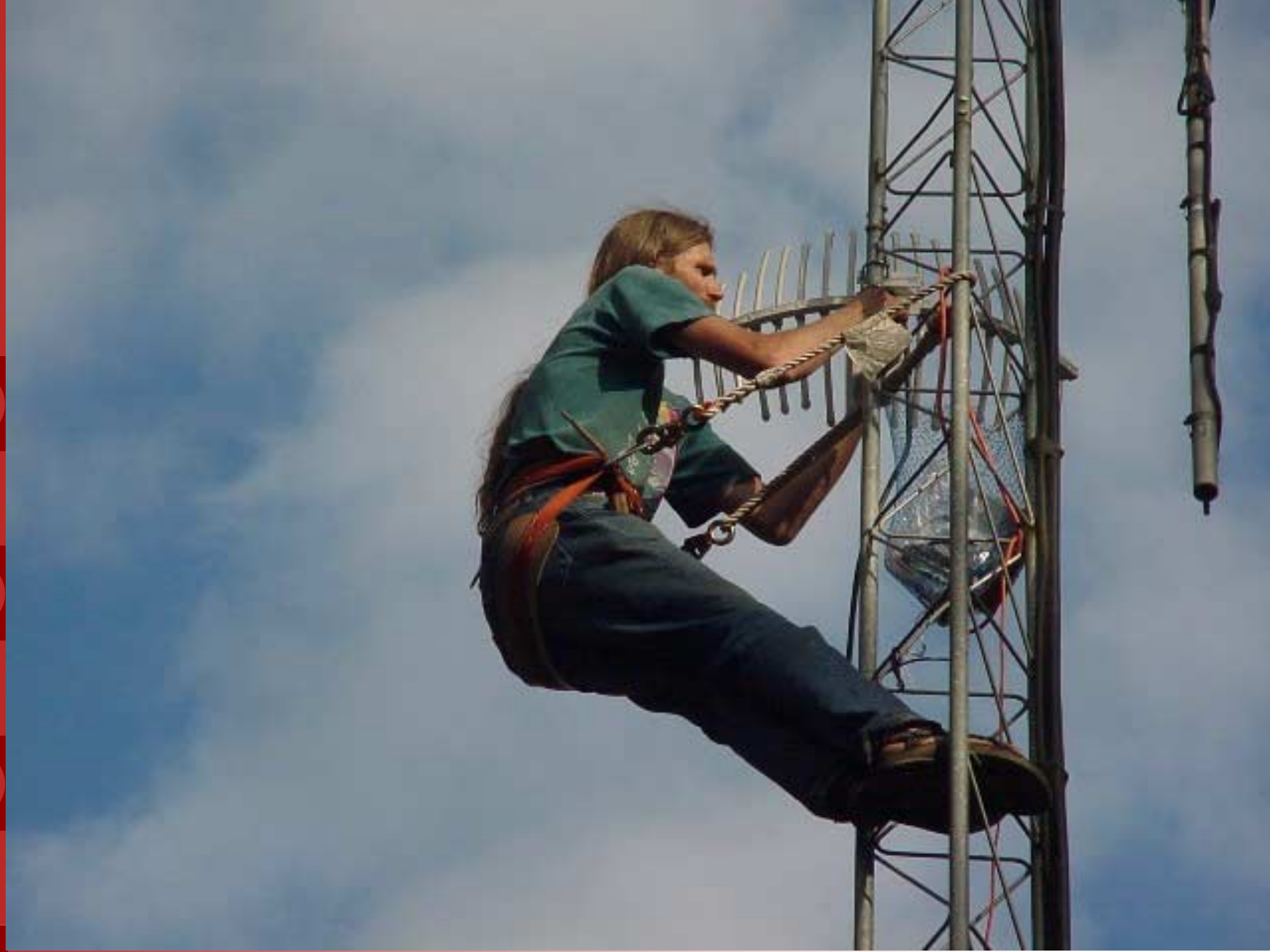
Robert Kelley, Ted Selker, Harvie Branscomb, on-line



Bhutan village rooftop with Yagi

# Developing Internet: Bhutan

- Between Tibet and India: 6000 villages have no phone
- Bhutan Telecom pilot project to demonstrate telephony in remote villages
- low cost, low density, irregular power supply
- extreme variations in elevation, temperature
- extreme lightning, high winds
- no fiber, some microwave long haul for telephony

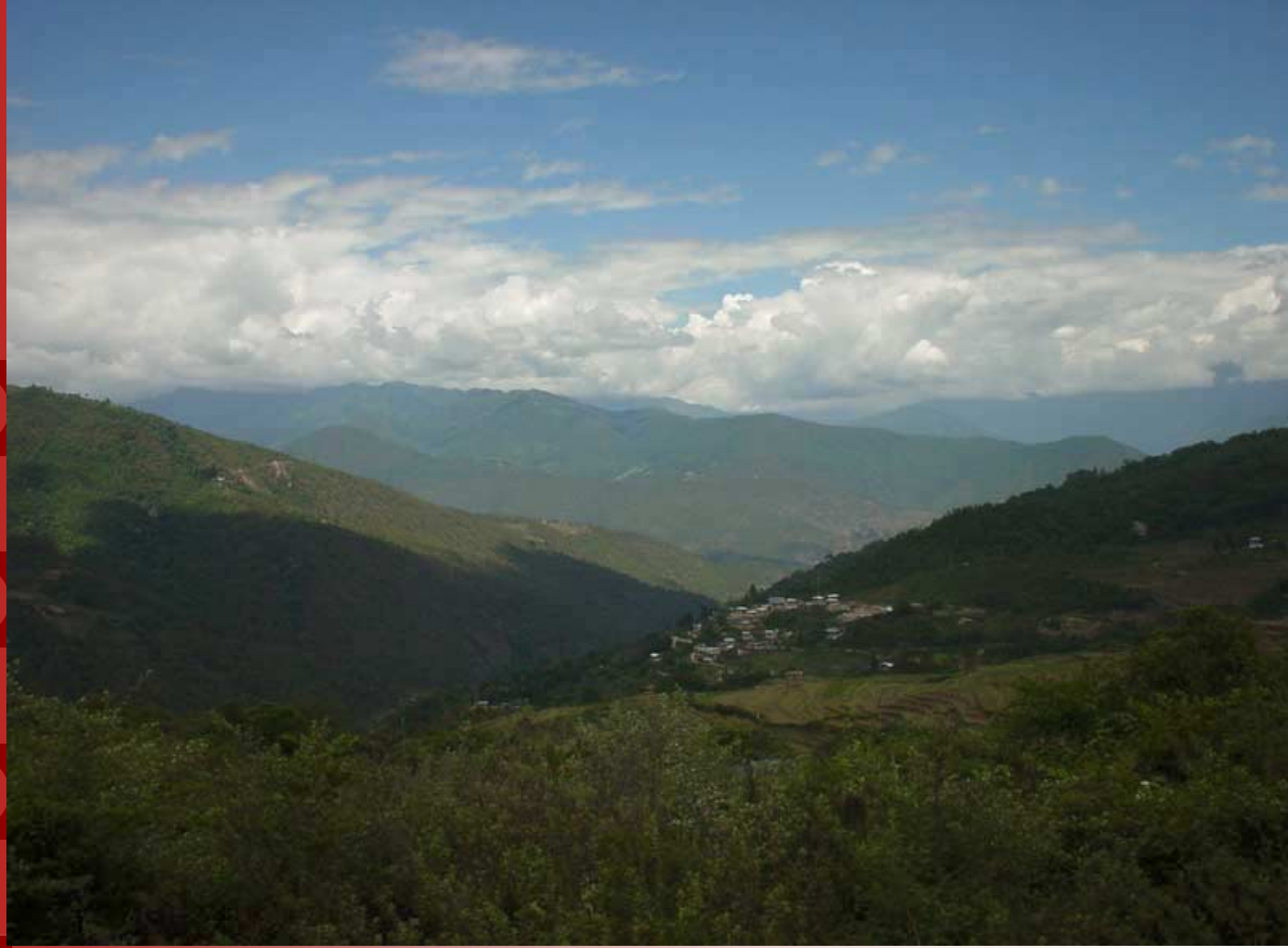


Clif Cox, 802.11b system designer, installer

# Bhutan Landscape

# Bhutan Telecom

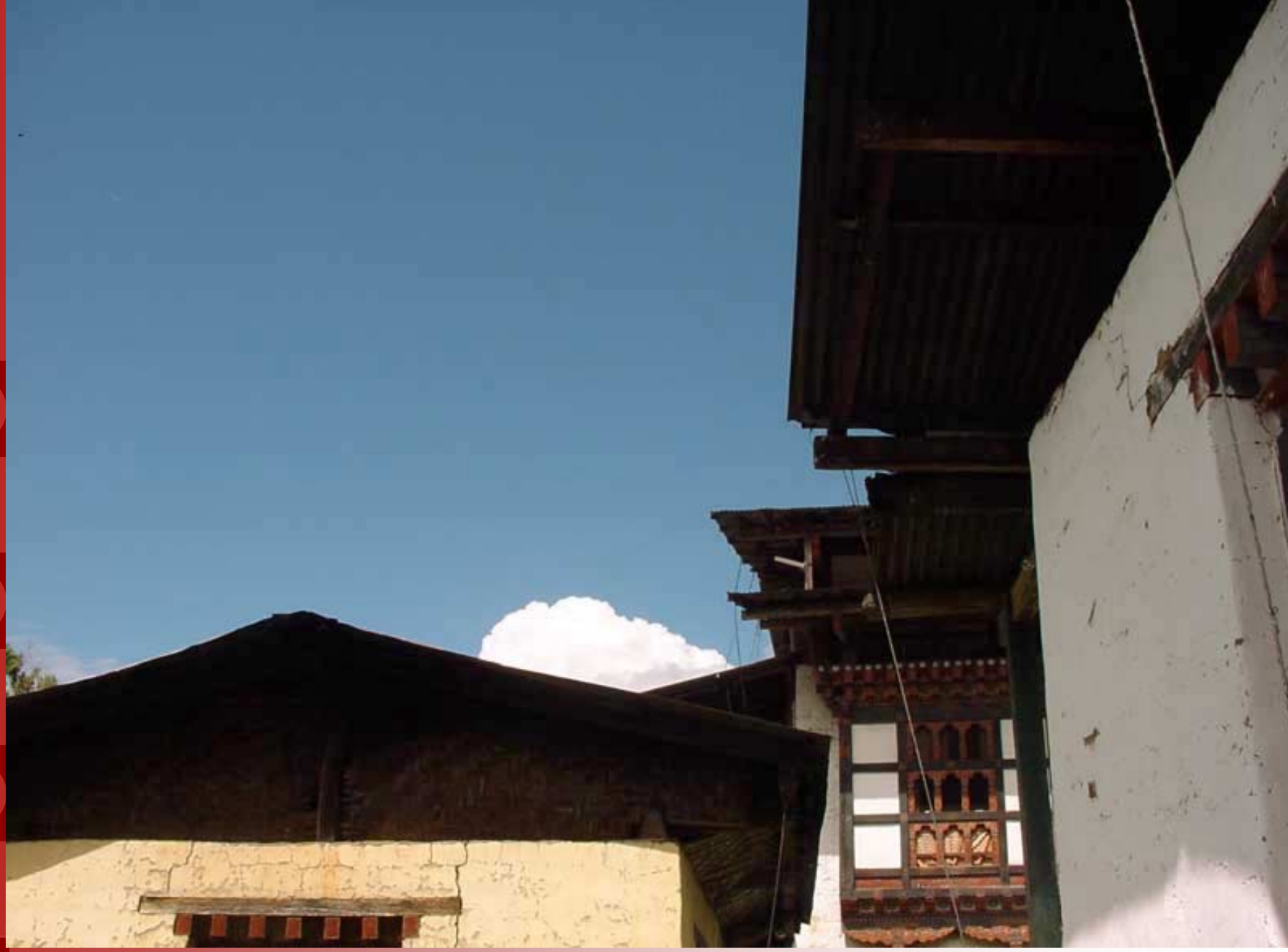
- Monopoly PTT thinking to adapt a bottom up solution to be used in a top down way…
  - Bhutan can control all use of RF
  - not necessarily interested in internet provision right away
  - prefers a solution which is flexible enough to track the future
  - does not want a research project-wants a telephone network
  - definitely does not want multiple innovative approaches



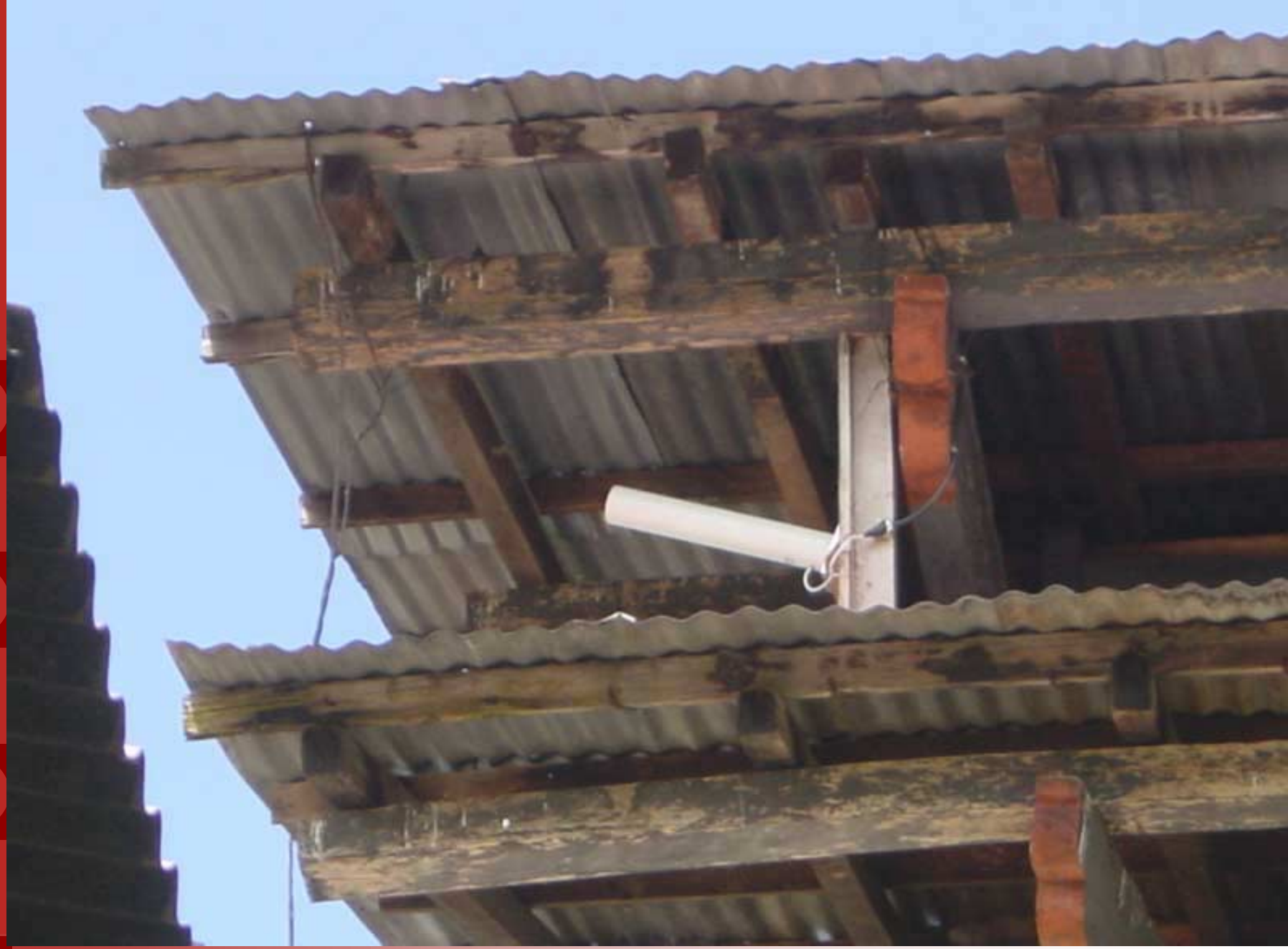
Village with wireless delivered telephony

# Bhutan searching for a telephone solution

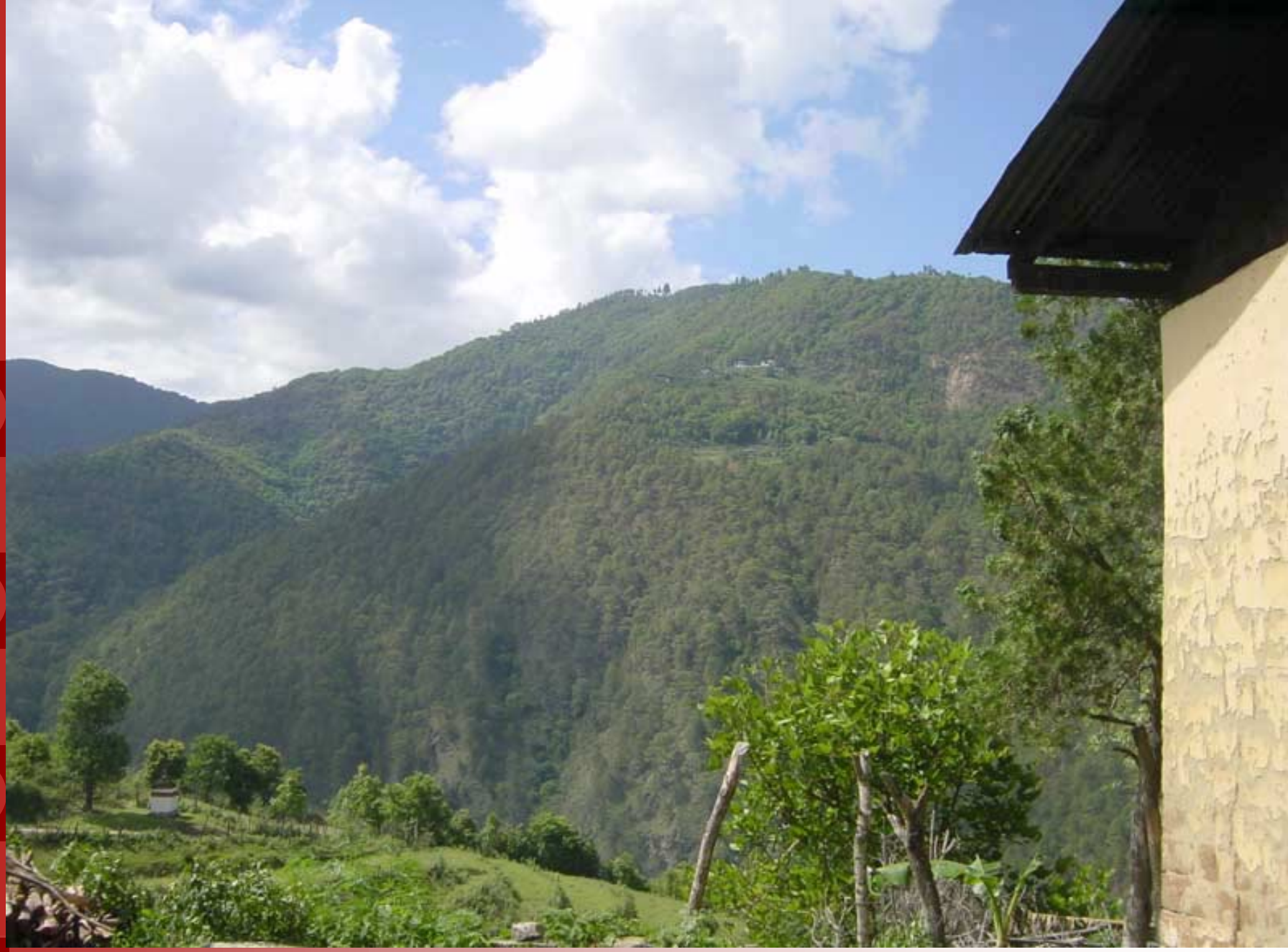
- almost no existing spectrum usage except satellite and broadcast TV,  radio and DRMASS at the low end of the 2.4 ISM band
- lots of cheap power but not reliable
- monarchy controls spectrum
- almost no legacy equipment in non-served areas
- 6000 villages to be served all at once
- uncertain interest in Internet
- expertise on technical systems is nonexistent in remote areas
- English is spoken regularly, except remote areas where phone service is needed



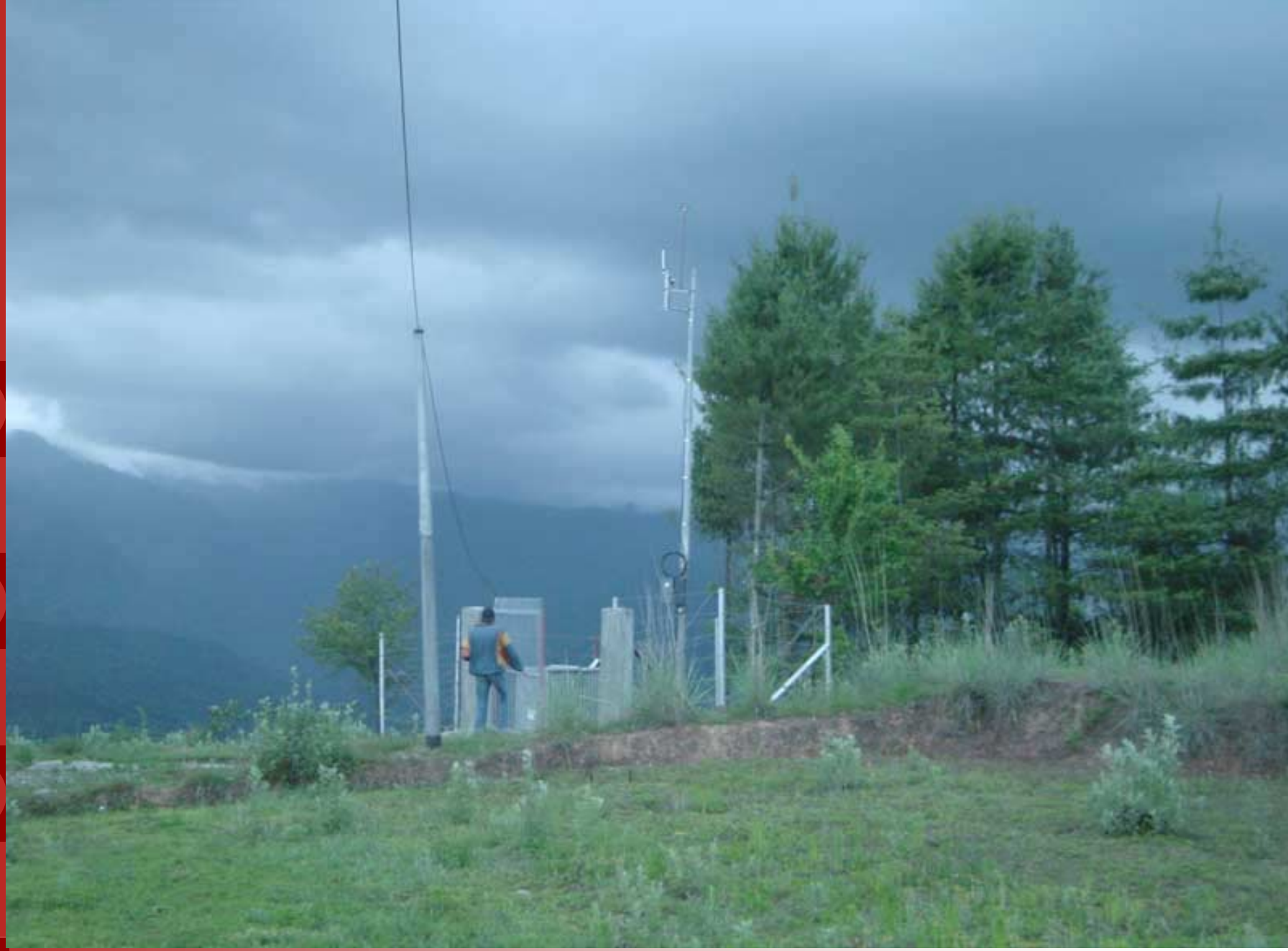
Bhutan house with Yagi



# Closeup of Yagi Antenna



Repeater on distant mountain top

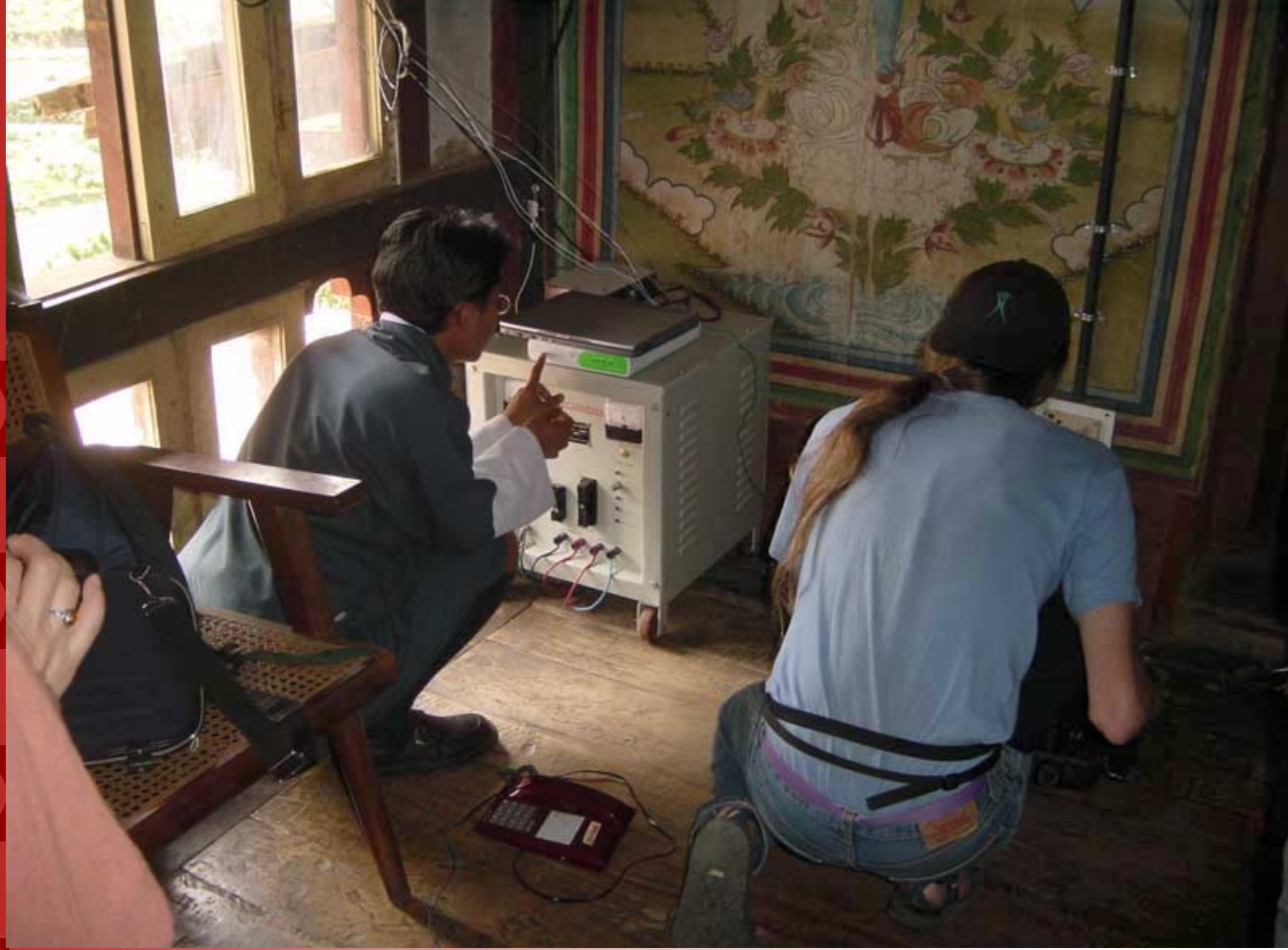


Repeater site, Talo Bhutan

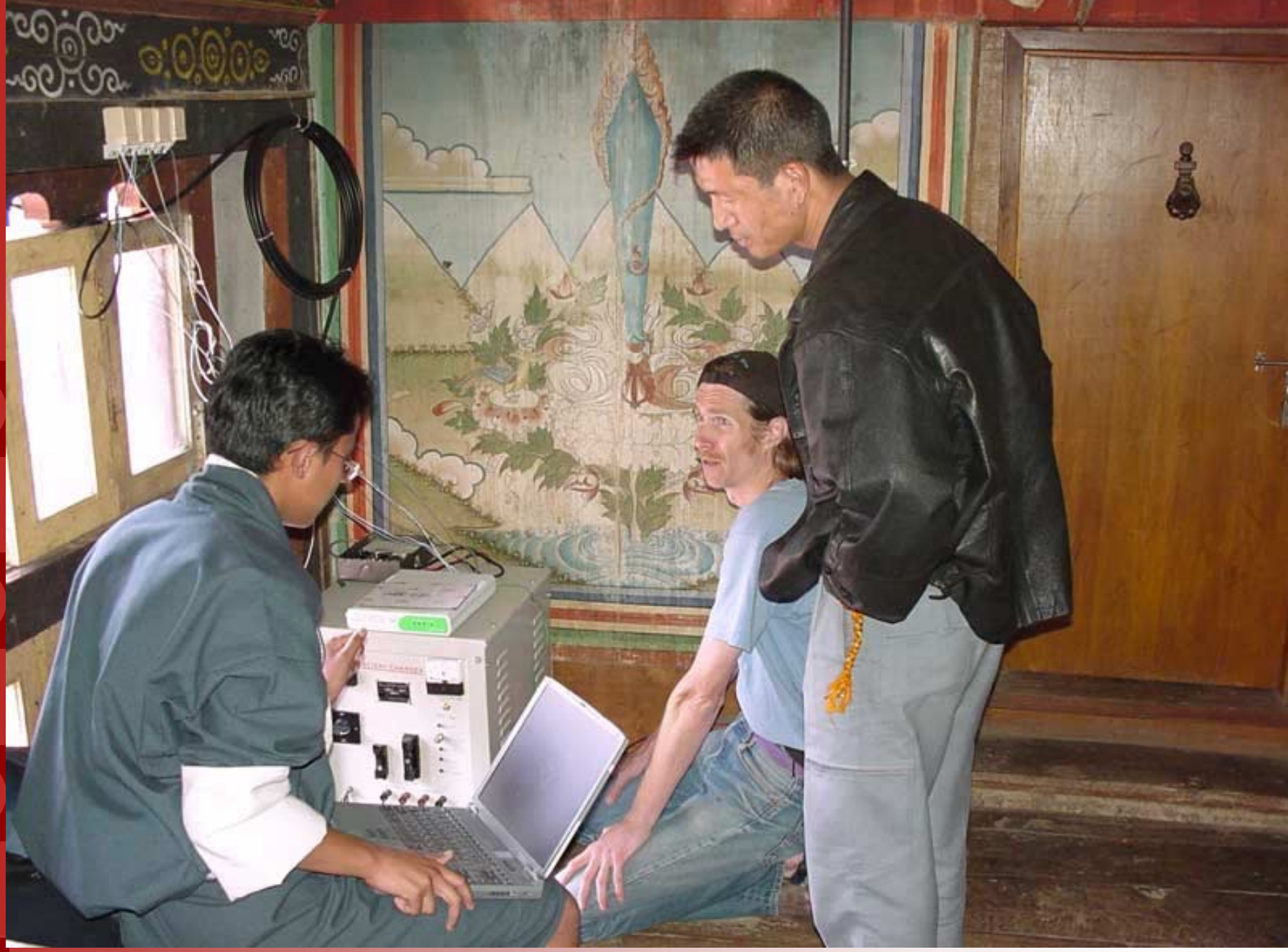
# Design of the BT VOIP Pilot Project

- installed ~10 Cisco bridges to extend the microwave net
- 802.11b clients with Vocaltec 8 line VOIP gateways
- powered by large batteries, sometimes solar
- last 500m distributed by wire

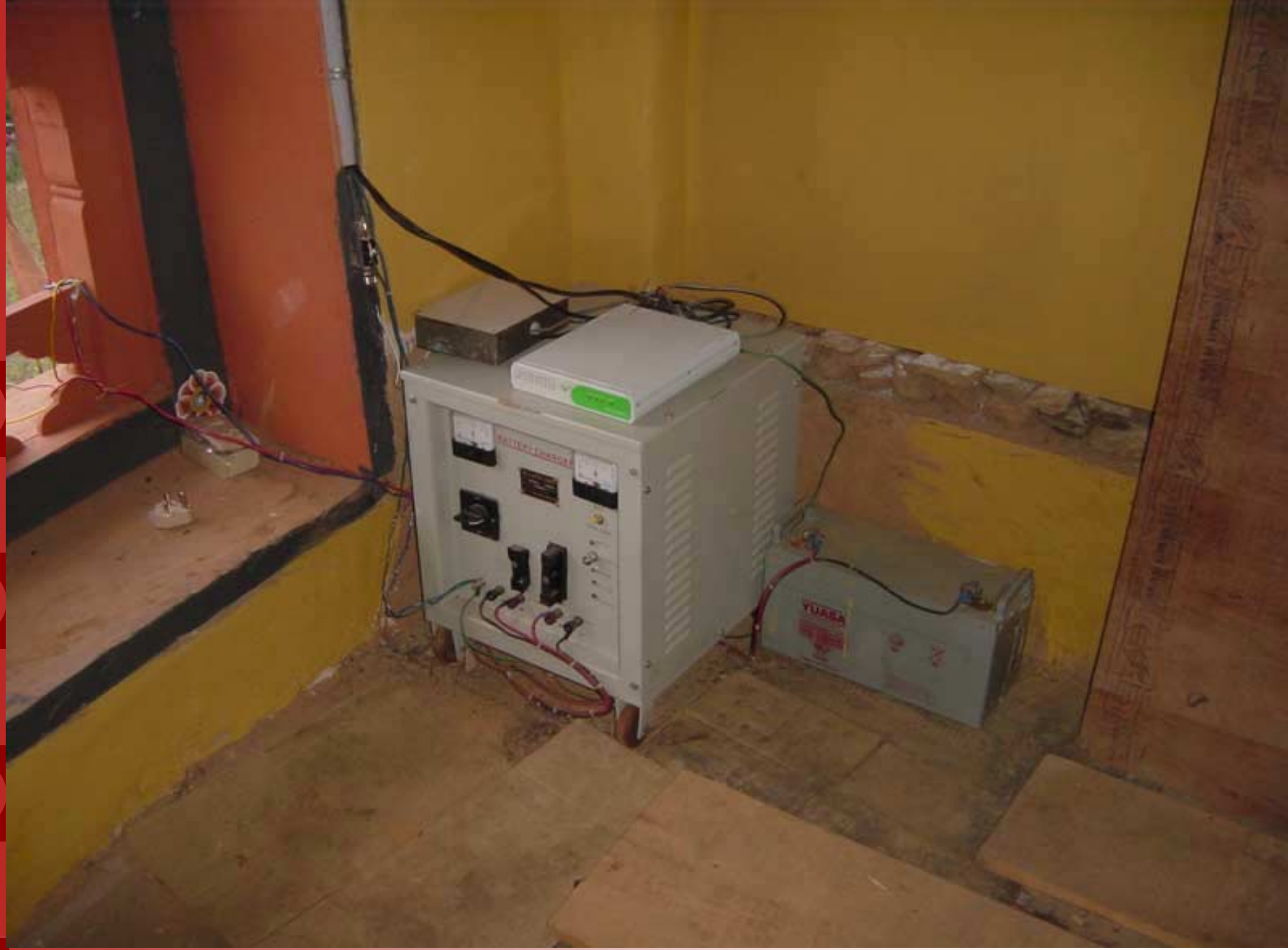
- Also testing GNU/Linux router approach with single board computer and PCMCIA POTS interface



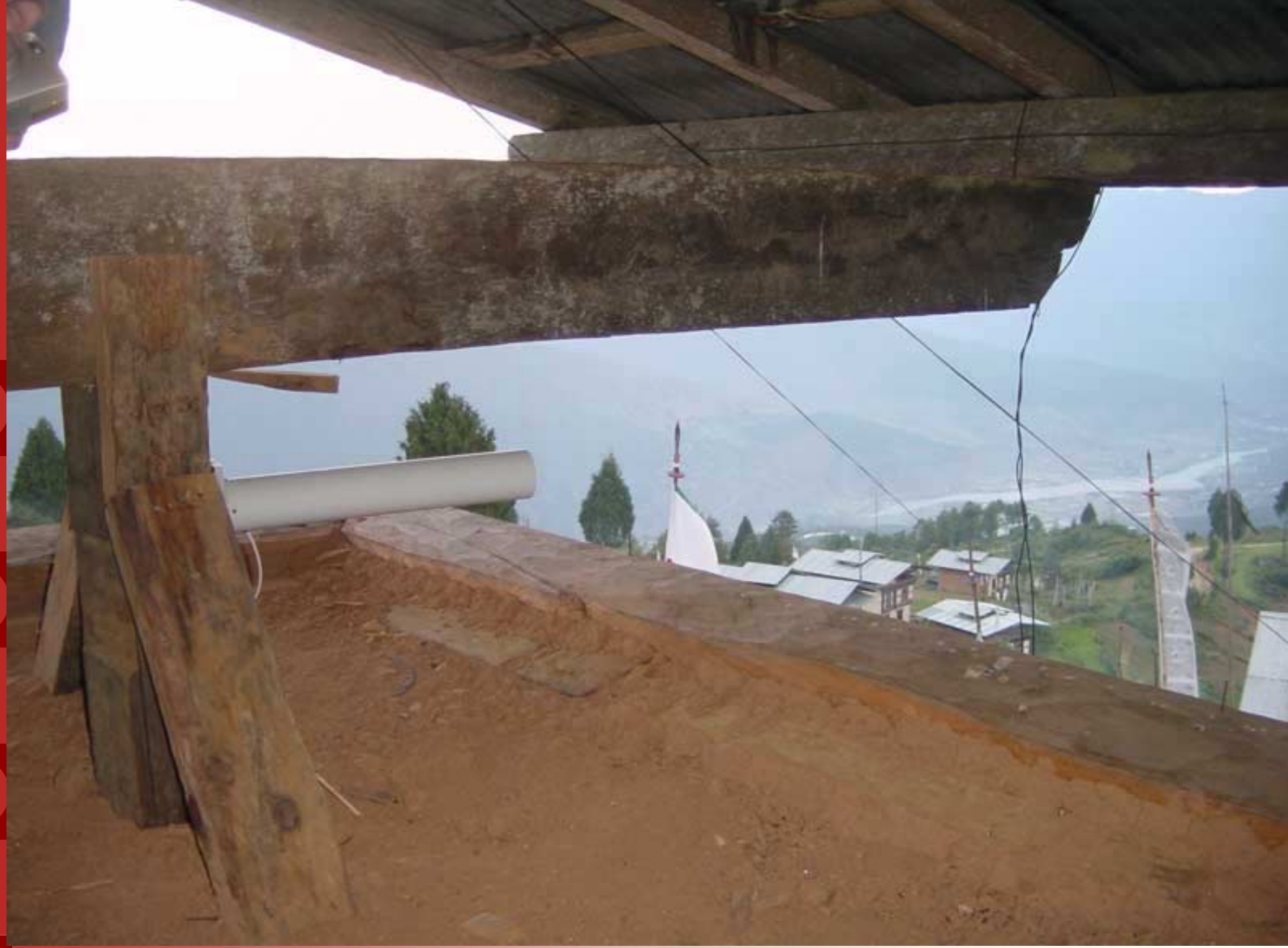
CPE and technicians Sitar and Clif



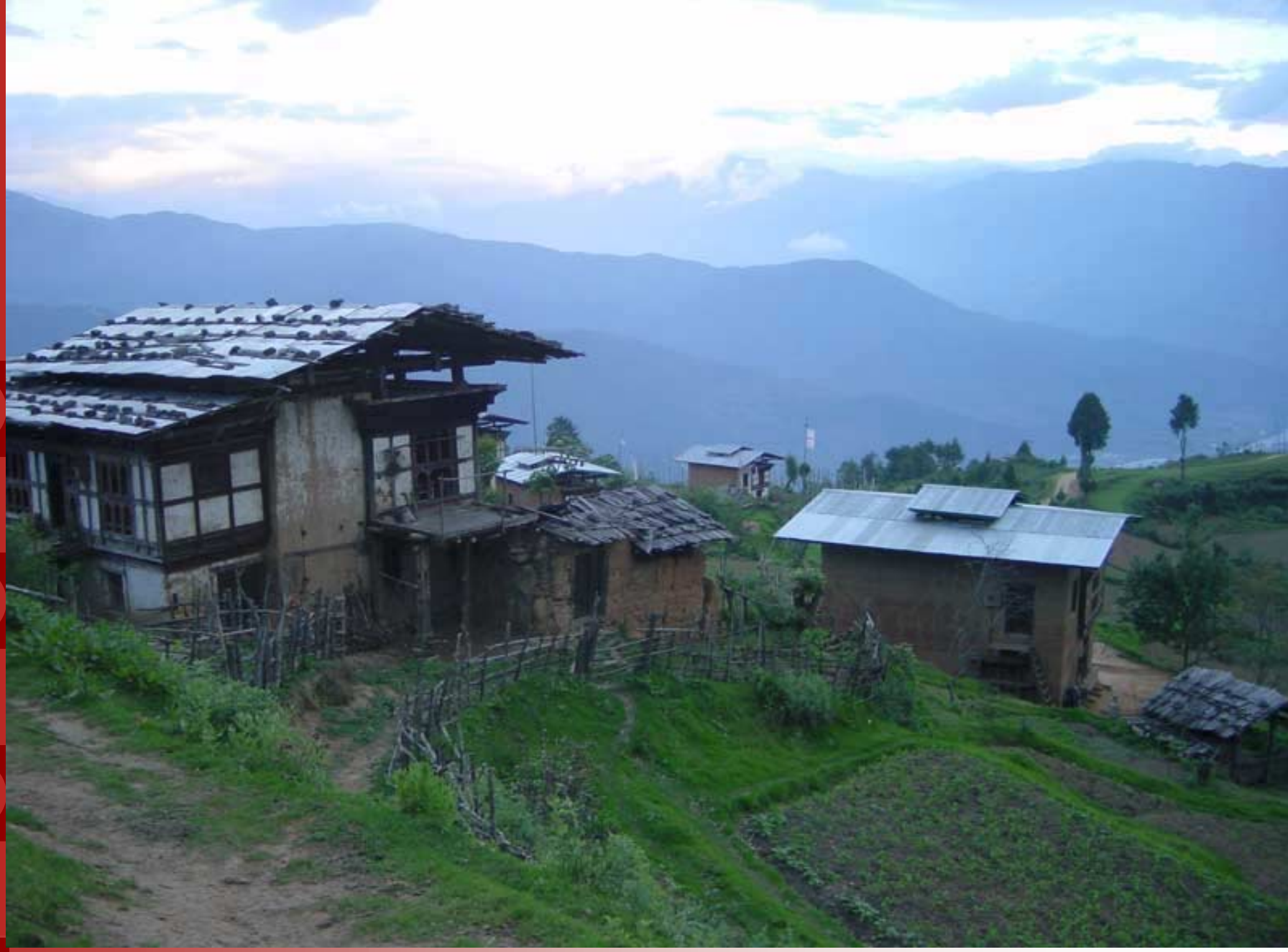
Sitar Clif and Sonam



Power supply, VOIP gateway, 802.11b client



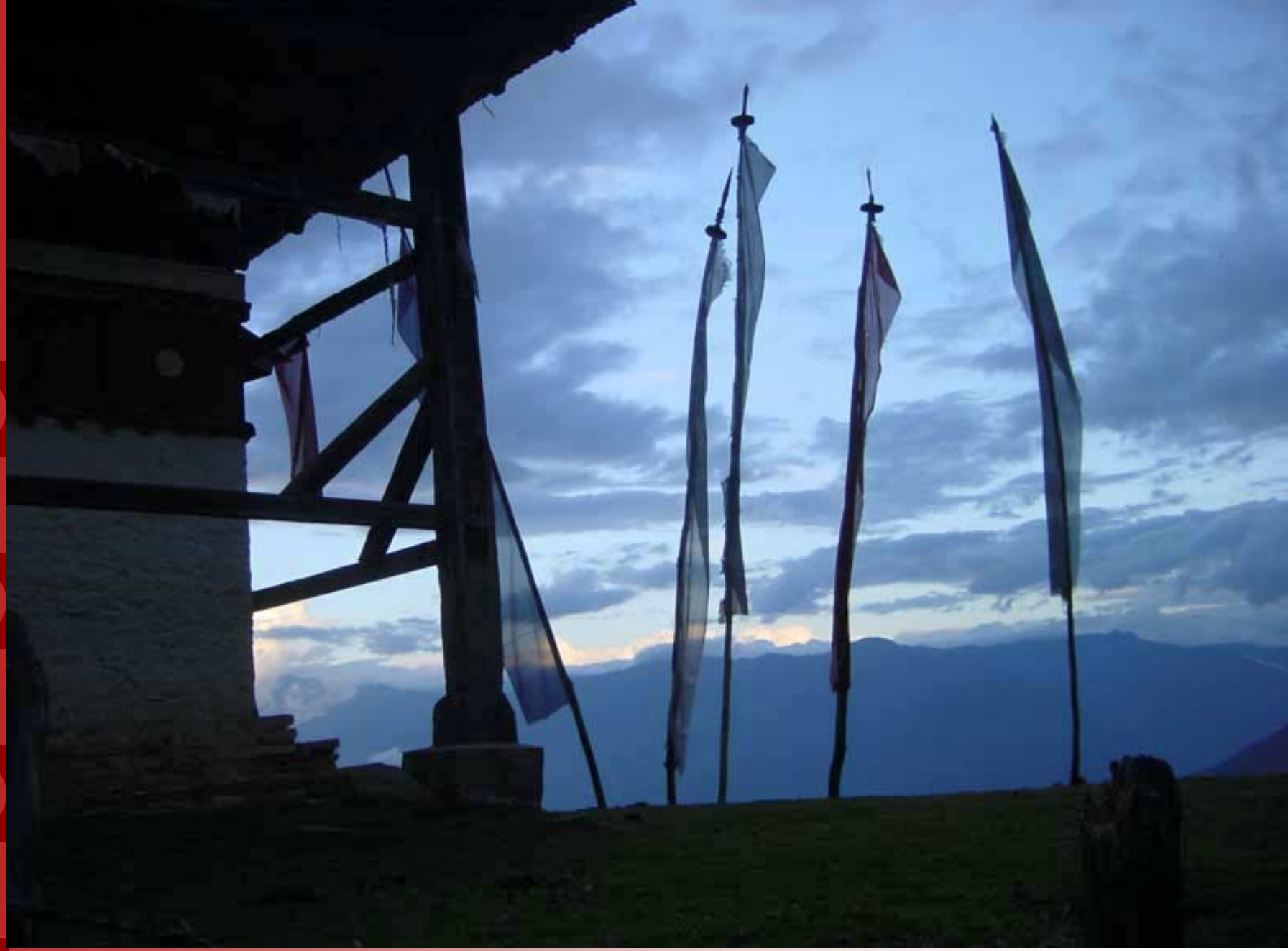
Yagi antenna mounted under roof



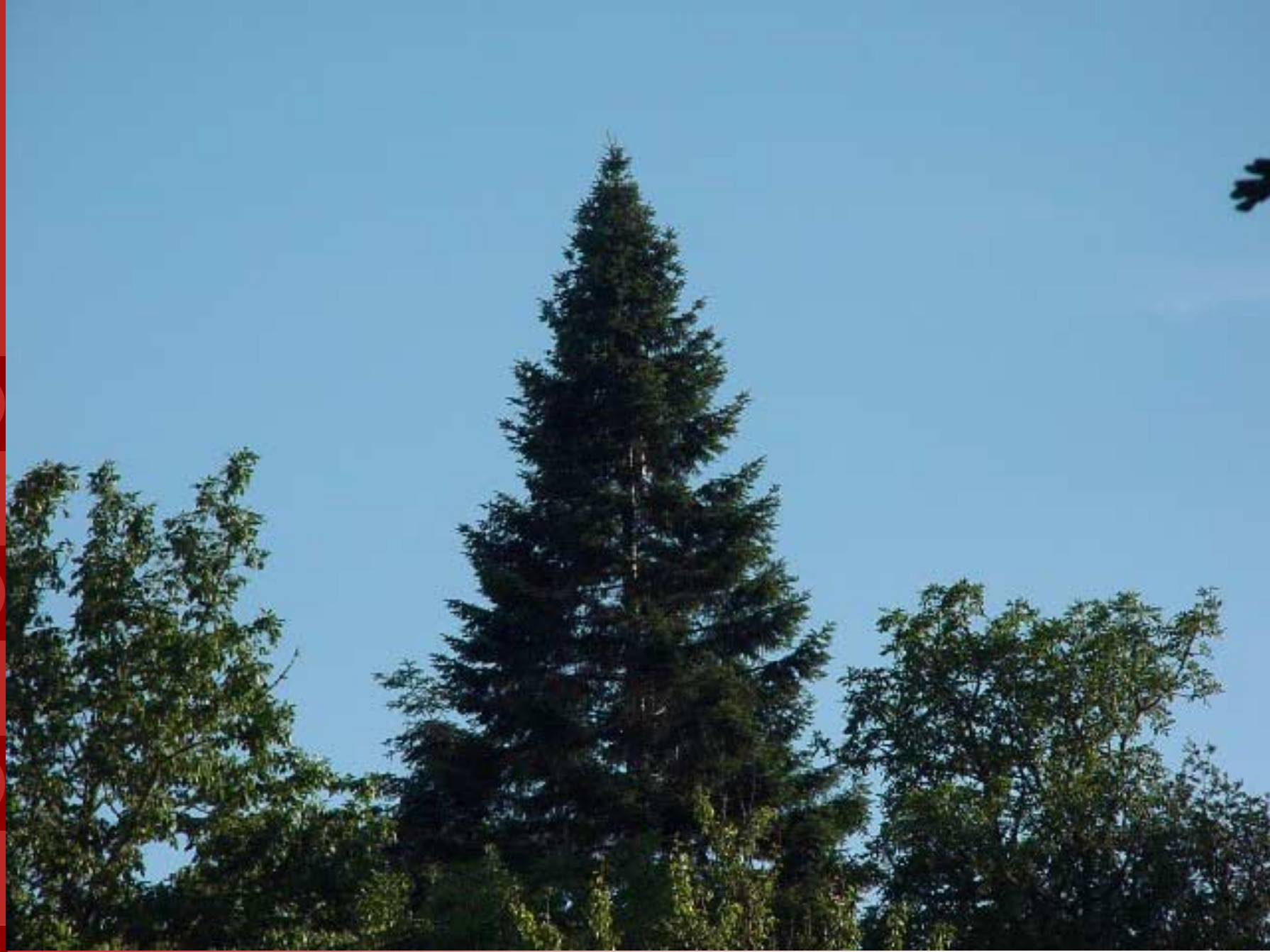
Talo, Bhutan

# Bhutan conclusions

- BT means Bhutan Telecom,IT means Indian Technology
  - much technology brought to Bhutan is not suitably designed
- the urgent needs of Bhutan cannot wait for research results from outside
- IP network by 802.11b works because (almost) no interference
- VOIP results look good, but some problems
  - possible telephony protocol incompatibility
  - QoS by preventing alternate traffic
- Regulatory restrictions harm usefulness of equipment:
  - bizarre connectors are very costly
  - frequency inflexibility is pointless in distant rural kingdoms



Sunset in Bhutan



A tree-(re)peater

# Questions for Discussion:

- Is there a technical advantage of direct sequence spread spectrumin the 802.11b implementation?
  - lost due to insufficient bandwidth allocated
  - lost due to use of common spreading code
  - lost due to incompatible narrow band emitters in same band
- Should connectivity services operate in ISM bands?
- Should there be new allocations for unlicensed use?
  - should they be arranged by type of modulation, not just playgrounds for all experiments… perhaps 802.16

# Hype leads to dreaming and fearing

- Price of equipment
  - finally reached level of a commodity, anyone can be an ISP
- public availability in US and Japan and elsewhere
  - this affects the probability that other ISPs can function reliably
- Fantastic investigative reporting in the press
  - (fantastic = fantasy)
  - diversion of paid for ISP services into free distribution by rogue grass roots wireless networks
  - piracy by monitoring wireless
  - leapfrogging the installation policies of local telco monopolies
  - software radio (perhaps the next buzzword to be misconstrued)

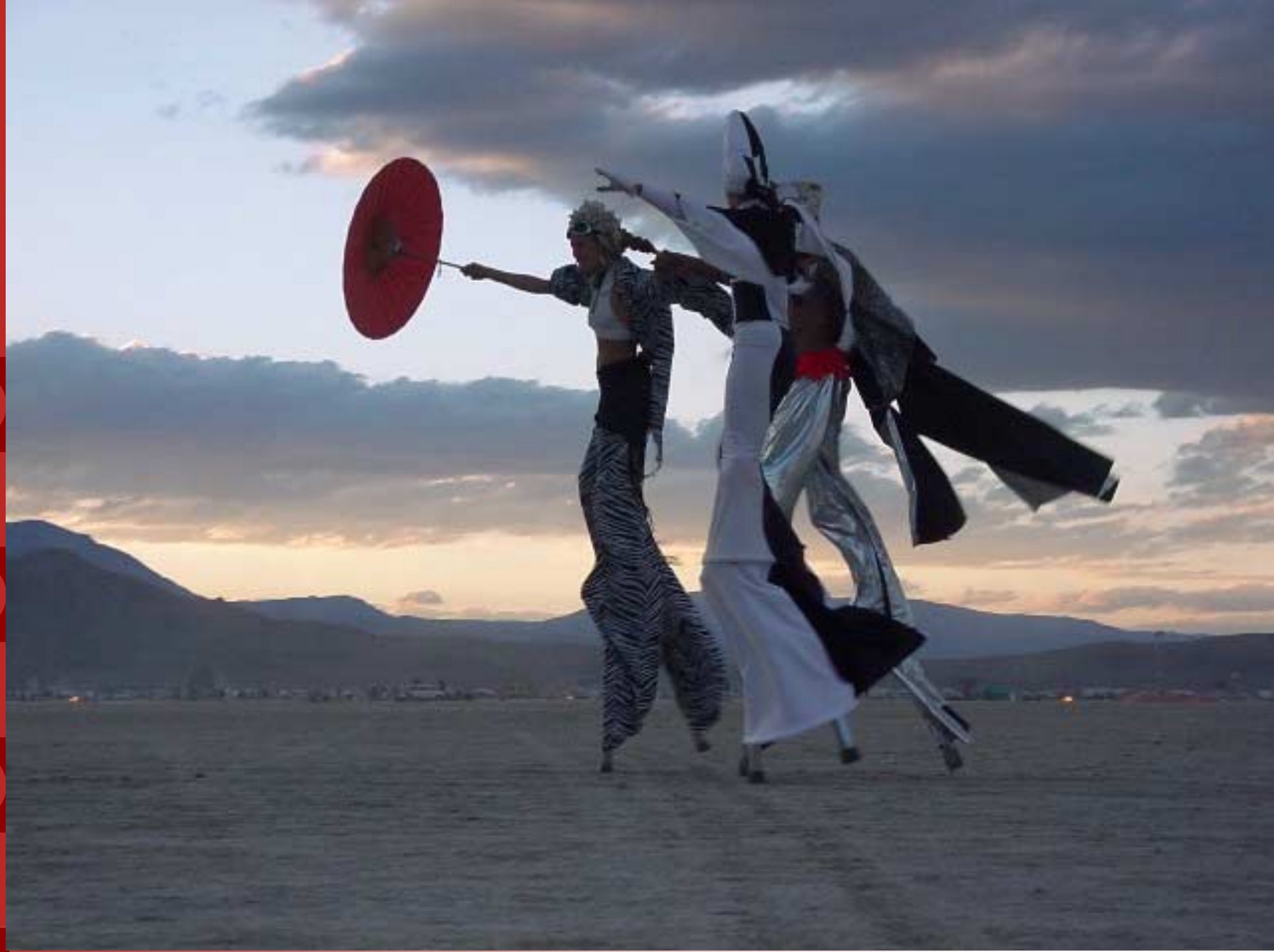
# More questions

- Does unlicensed wireless serve a role as a transient catalyst?
  - Proving that the market exists
  - finding the customers
  - demonstrating the applications
- Will wireless equipment be recycled after it is replaced by wire/fiber?
  - moved to a lower density more rural location and reused
- How can mobility compete with fixed applications without regulatory restraint?

# Key to practical use of unlicensed wireless

- The best solution is to allocate new spectrum with new regulations so the technology can be used to assist in sharing.

- meanwhile...
- Keep expectations low, or operate in clean spectrum
- monitor the activity in the service area, and
- expect to reengineer the network frequently over time
- encourage end to end security
- encourage mobility at the client to obtain adequate quality of service



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