Enabling Sustainable Rural Wireless Telemedicine at Aravind Eye Hospitals

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Sustainability

• Since WW2, many multilateral aid mechanisms have emerged
  – e.g. World Bank, UNDP

• Sustainability is of primary concern for development projects under aid
  – Typical roadmap: pilot first, then scale and sustainability

• In practice, difficult to achieve sustainable ICT projects
  – Financial constraints
  – Operational constraints
Three Principles

• View project as optimization of existing system
  – Easier to achieve community buy-in

• Financial self-sufficiency
  – Cash-flow positive

• Operational self-sufficiency
  – Build local support
  – Increased component robustness
  – Provide easy-to-use IT management tools
Background: Blindness in India

15 Million blind in India\(^1\)

Background: Blindness in India

Cataract

70% of blindness is treatable

Refractive Error
Background: Eye Doctors in India

- 10,000 eye doctors for 1 Billion people
- 70% of total population is rural
- 90% of all eye doctors are in urban areas
- 1 eye doctor for 700,000 people in rural areas!

Background: Eye Patients in India

“If we go there, we might end up eating there and then there will be other expenses, we would have to spend some 20 – 30 rupees plus other expenses.”

Patients waiting at the hospital

“Sometimes we are unable to see the doctor, so we may have to stay there for two days, which is expensive for us.”

Patients often choose not to go until too late!
Immediate Need

Increase the utilization of doctors
Aravind Eye Care System

Mission: Eradicate Needless Blindness

Coimbatore (1997)

Madurai (1978)

Tirunelveli (1988)

Theni (1984)

Pondicherry (2003)
Approach 1: Rural Eye Camps

But only reach 7% of targeted population
Approach 2: Telemedicine from Rural Vision Centers

- Rented room in village home (Rent: $50/mo)
- Staffed by 2 people (Total Salary: $100/mo)
- Equipment: Slit lamp, refractive testing setup, lens grinder, PC with webcam for telemedicine, etc. (Total setup: $11,000)
Advantages of Vision Centers

• Extend Reach
  – Increase utilization of eye doctors
  – Save travel time and expense for patients

• Permanent Presence
  – Eye camps not as effective
  – Sustained awareness
  – Promotes care-seeking behaviour
  – Supports capacity building
Vision Center Patient Flow

- Rs. 10 (25 cents) per consultation
- Medicines extra
- Spectacles extra
- Referrals extra
What Networking Technology to use for Telemedicine?

• Generally the answer has been whatever is least expensive of the options available.

• Aravind initially chose CorDECT WLL
  – Good technology but outdated; many issues

• Our solution: Wifi for Long Distance, or WiLD
  – Modified WiFi MAC software as there are issues with standard WiFi in long distance settings
CorDECT’s Disadvantages

• Requires base station => Complex equipment
• Licensed Frequency => Subscription fees
• Carrier-operated => No operational freedom
  – E.g. A vision center had to wait 6 months for carrier to provide coverage
• Limits to coverage (10Km line of sight)
• Low performance (35 – 70 Kbps)
WiFi

• **Advantages:**
  – Unlicensed Frequency
  – Grassroots style deployment
  – Manage own deployment & expansion
  – Standard low-cost equipment

• **Disadvantages:**
  – Not designed for long range coverage

• **Our solution: WiLD**
  – Tradeoff Omni-directional coverage for Point-to-point coverage
  – Modify software to get high-bandwidth over long distances
Aravind Theni Telemedicine Network
Financial Self-Sufficiency

Data for the calendar year 2007. All values in US Dollars

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<th>Andipatti</th>
<th>Ambasam</th>
<th>Bodi</th>
<th>Chinna</th>
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<td>Income</td>
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Four out of five are cash flow positive
Bodi Financials

- Cash Flow Positive: 1,157 (excluding network costs)
- Consider Network Costs:
  - OpEx:
    - $18.50 per link per year for maintenance
    - Two links (hops) = $37
  - CapEx
    - $1800 (includes shared tower)
    - CapEx translates to $385 per year assuming 8% interest, 5 year lifetime (everything but tower), and 20% salvage value

- Cash flow positive including both Network OpEx and CapEx
Bodi Financials

• Cash flow after Network costs: $728
• Vision center CapEX is $11,000
• If we assume optimistically a 50% salvage value after 10 years, this translates to $1200 per year
• Losing $500 a year
• Not profitable but close
  – Increasing patients will help

• So once created centers are sustainable
  – Need initial aid
Operational Self-Sufficiency

• Training
  – Once trained, they are likely to leave

• IT Management Tools
  – Reduce the dependance on trained staff

• 3-Tiered Support system
  – Tier 1: Aravind
  – Tier 2: Local Vendor, Tulip IT
  – Tier 3: TIER Group
Operational Self-Sufficiency

Migration of Responsibility

TIER, UC Berkeley
Aravind
TulipIT (Local Vendor)

Maintenance
Management
Installation
Equipment Supply

Jan’06 – Jun’06
Jul’06 – Dec’06
Jan’07 – Jun’07
Jun’07 – Dec’07

2007: 5 more clinic links
Patient Throughput

90,000 patients screened; vision restored for 15,858
Patient Impact

• 90,000 patients screened
• 17,678 diagnosed with vision problems
• 15,858 patients got vision restored

• 72% are new patients every month
• 28% are follow-up patients every month
  – Higher quality of care

• An Aravind study revealed that 96 percent of Aravind patients who get cataracts stop working. Among those who lost their jobs, about 85 percent of men and 58 percent of women who get surgery return to wage-earning activities within a week.
Revisiting Three Principles

• Optimization of Existing System
  – Improve access to existing doctors
  – Increase their utilization
  – Better than prior approaches
Revisiting Three Principles

• Financial Self-Sufficiency
  – Reduce deployment cost by choosing WiFi
    • Low-cost equipment, unlicensed spectrum
    • Easy to train staff
  – Operational freedom allows access to more paying patients
    • Clinics do recover network OpEx and CapEx
    • But no CapEx to set up the clinic
Revisiting Three Principles

• Operational Sufficiency
  – Training of staff
  – IT management tools for (semi) automated diagnosis, recovery
  – 3-Tiered support system
  – System now handed off to Aravind
Summary

• Challenge
  – Need to multiplex doctors via telemedicine
  – But connectivity too expensive, too complex in rural areas

• Idea
  – Use off-the-shelf WiFi with modified software for low-cost high-bw connectivity
  – Provide support through training, tools, and 3-tier support system

• Impact
  – Deployed and handed off system to Aravind
  – 90K patients screened; vision restored for ~16K patients
  – Aravind scaling the system to 50 centers covering 2.5 Mn people