Technology Infrastructure and Case Analysis

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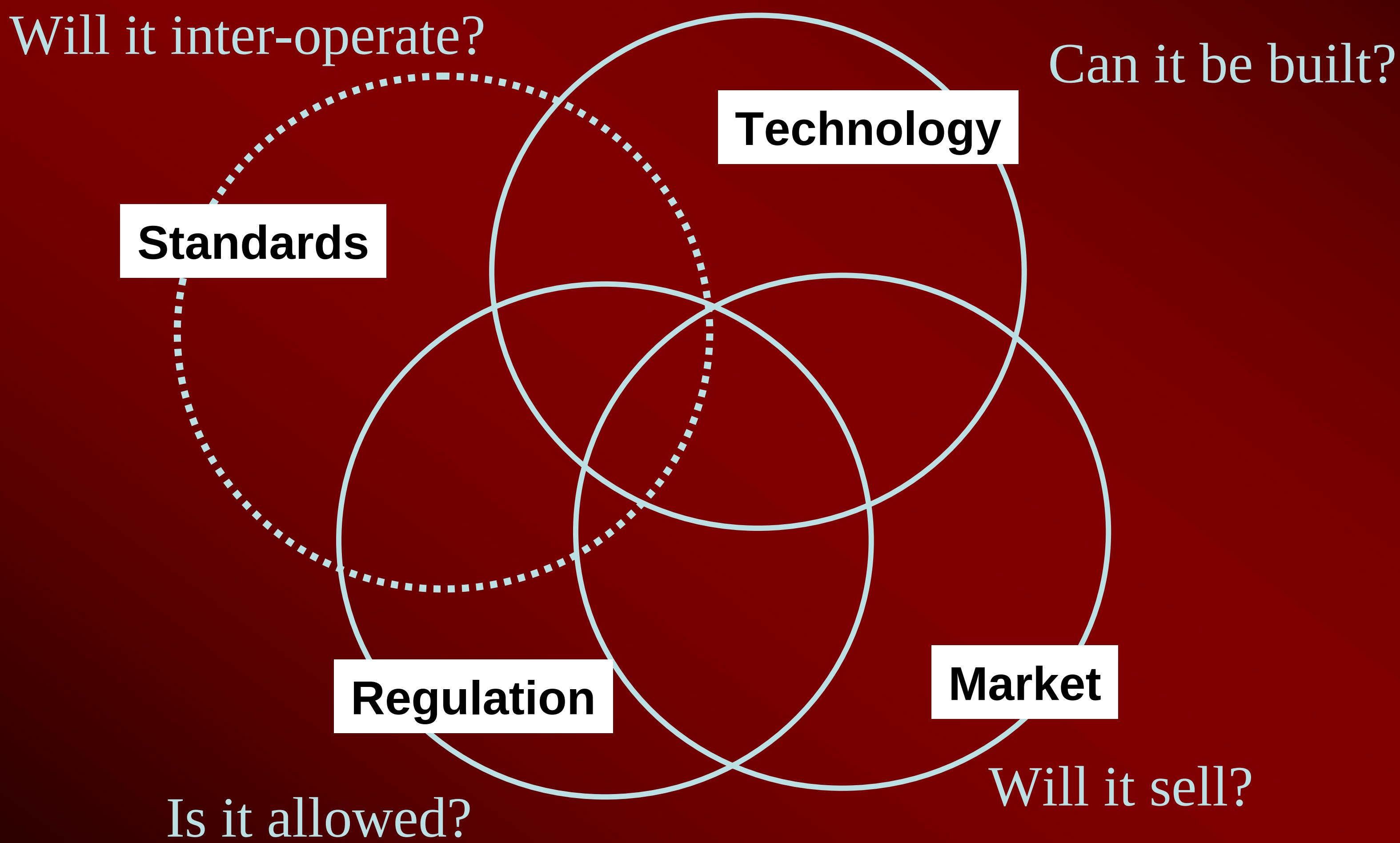
Requirements for Success of a Service



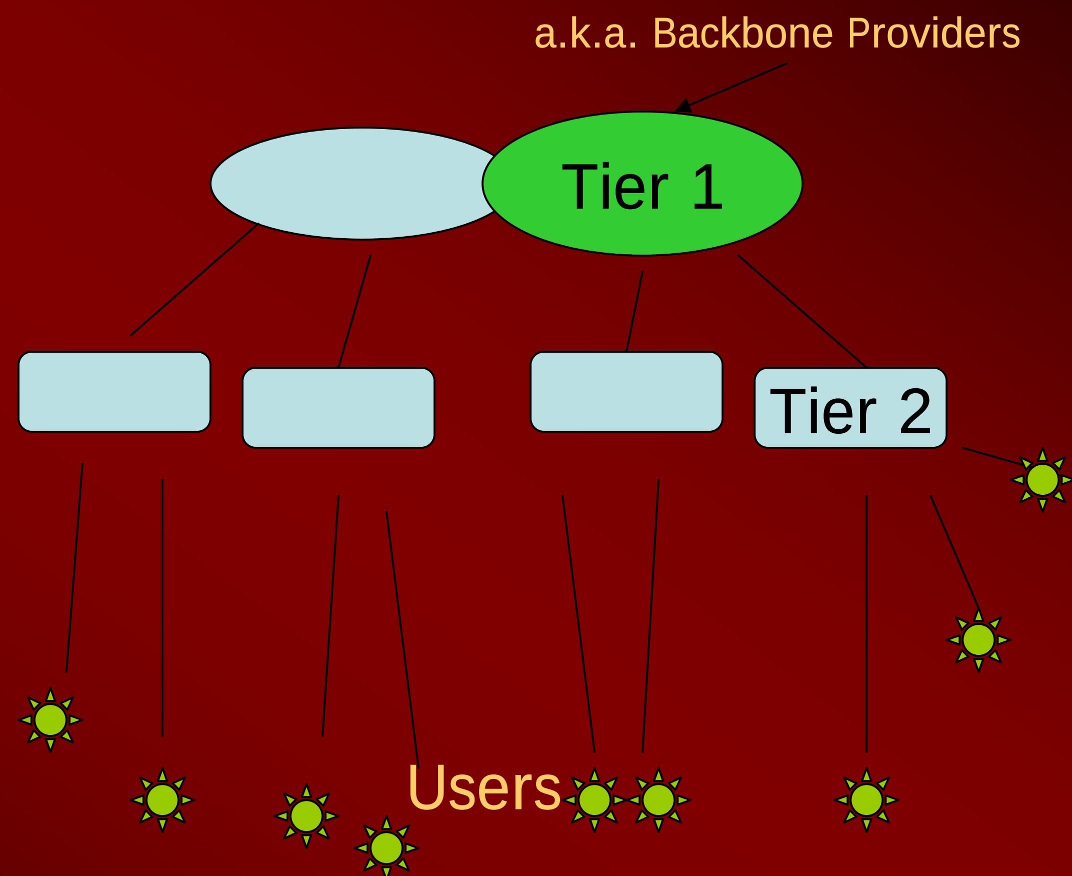
Adapted from: Leon-Garcia

Novel ICT (?)

- Device cost: 10-100 times reduction
- Infrastructure cost: 10-100 times reduction
- Device power: 10-100 times lower
- Speech recognition for obscure languages and dialects

What is the Internet?

- The global (public) network built from hundreds and thousands of internetworking independent networks.
- No single entity “runs” the Internet
- Operates on standards
- Built on a modified hierarchical structure
- <u>Packet Switching</u>



- There are often more layers
- There can be interconnections other than at a backbone

The Internet Needs 3 Things to Run

- PROTOCOLS – Standards for data-centric design
  - Expectations of how things should work together
    - Layering
  - Robustness Principle
    - "Be liberal in what you accept, and conservative in what you send." – Jon Postel
  - Resiliency – distributed architecture
  - Limits Monopolies
  - NO ONE OWNS THE INTERNET
- PEOPLE – Trust
  - Addressing schemes and registration
  - End-to-end design
- PAYMENTS – Boundaries
  - Limits of Responsibilities
  - Inside the core, is like a black box ("The Cloud")

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"Call Completion" / Transaction (aka Settlement) Charges

- Mail – postage stamp mechanism
- Telephony – cost sharing mechanisms (vary)
- Internet?

- What are the costs?
  - Calling – sharp falls over time
  - Mailing – increasing over time
  - Faxing – not going away anytime soon
  - Email
    - Is it really free?
      - Access
      - Upstream TCO (ignoring SPAM, for now!)
      - Time

Peering – Internet “Call Completion”

- Where backbones come together
  - Major design issue (relates to cross-connection)
- Public Peering – fallout of the public history of the Internet
  - Network Access Points (NAPs)
    - Started with 4, but now there are more
    - Usually done by equals
      - Give as much traffic as receive
- Private Peering
  - Commercial (private)
- International peering is more limited (links are much more expensive)

TCP/IP

- Suite of protocols for networking
- Based on logical address for devices
- Most popular standard worldwide – built into most OS
- Like most other packet switching, is
  - o Connectionless
  - o Statistical (non-deterministic)
    - – No inherent Quality of Service (QoS)
  - o Most of IP routing is unicast
- Routers pass packets along towards the destination *hop-by-hop*

Internet – Good for what it was made for

- Best-effort data network
  - Scalable
  - Resilient
- New trend – Everything over IP (XoIP)
  - Voice – Circuit switched
    - Much less than half the traffic (on average)
      - Growth of ~25% vs ~100% (?) for data
    - But, is most of the revenue for carriers
      - Suppliers' "killer app"
      - For users, *email* and *WWW* are the killer apps (legal, anyways)
    - Internet Telephony is not the same as VoIP
- Innovation can occur at the edge, in small pieces
  - End-user applications and revolutions

ICT not just Computers and Internet…

- Sensors on chip => very cheap if integrated
  - Basic: temp, humidity, pressure, moisture, light…
  - Moderate: acceleration, magnetic, position
  - Simple chemical: gases, smoke
  - Complex biological: toxic agents
- Actuators: control environment as well
  - Harder and costlier, often require more human interface
- Examples
  - MEMS for low-cost "lab on a chip" and drug delivery
  - Sensors
    - Environmental or food quality (or security)
  - Remote sensing for predicting and enhancing crop yields
  - Leveraging "cyber-infrastructure" for science and policy
    - Healthcare, e.g., Epidemiology and Patient Management

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Hypothetical WiFi Kiosk

- Consumer Access Points are now < $50 (only!)
  - What else does it take?
  - What range does it cover?
    - Number of Users
      - Band overlaps and congestion
    - FCC vs. ETSI regulations on power emissions
  - Uplinking
    - IP address space
  - "Now What" Syndrome – need user h/w, s/w, etc.
  - Business Plan ?
    - Capex is less than half of "broadband" costs

Leapfrogging

- Countries need not just be followers
- Role for new / advanced technologies
  - Can involve R&D
    - Speech
    - Power systems
    - Wireless
- Role of (need for) new business models
  - Open Access

High Tech to “Low Tech”…

Agriculture in Perspective

- US today
  - ~1+% of population
  - ~2+% of GDP
- India
  - 65-70% of the population
  - ~20% of GDP

- Rhetorical Q: What paths or trajectories are sustainable?

Roles of Advanced Technologies

- Increasing output (yield)
  - Productivity
  - Sustainability
  - Optimizing inputs
- Improving the supply chain from the farmer's perspective
  - Price discovery
- Land ownership and empowerment
- Education

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Feeding the World

- Feeding the World
  - o Population has grown tremendously, and expected to peak ~10+ billion (growth ~50% more)
  - o Arable land peaked roughly 1980 (~10% of total land)
  - o Thus, *need more output from the land*
- Poverty and Hunger are linked in the developing world
  - o Malnutrition (undernutrition) is a key determinant of health, economic productivity, etc.

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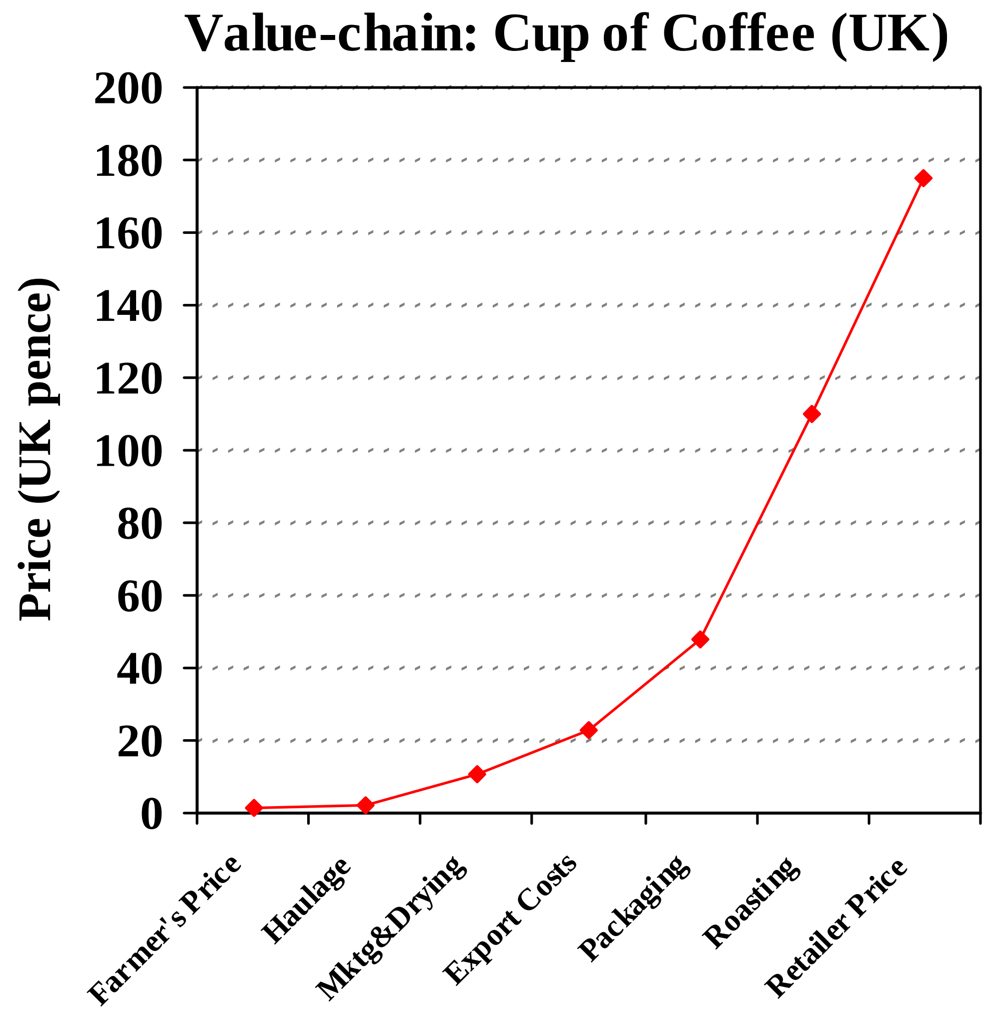
Making a Living

- How many people are needed to grow enough food?
  - Is it a local, regional, or global market?
  - Globally
    - 4% of economy
    - Over 1/3 the jobs (?)
- How do we obtain fair prices for farmers?



Source: Guardian

Sustainability and Agriculture

- Soil cannot produce more than the inputs it takes in
  - Else it will degrade and require ever greater inputs up to the point of unusability
  - In addition to how much gets taken out, when, where, how fast, and in what form it gets taken out affect soil productivity and capabilities
- Sustainability is a fundamental part of long-term agriculture, which is based on:
  - Preserving the natural resource base
  - Maintaining the soil's productivity
  - Maintaining environmental quality
  - Alleviating human drudgery and suffering – making agriculture a viable and respected livelihood.

Green Revolution

- Achieved by growth of input-responsive varieties of grains on fertile soils significantly enhanced by fertilizers and irrigation
    - Differences in these inputs explains variances in productivity (in part):

Source: FAOSTAT data (2004)	**World Cereal Yield (tons/ha)**
World average yield	3.31
Highest yield (Belgium)	8.48
Lowest yield (Botswana)	0.24

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Water for Irrigation

- One of the major inputs for agriculture
- Either costs a lot, or is subsidized
  - Estimated 1+% of Indian GDP as subsidy
- Not all solutions need to be high-tech
  - E.g., “MoneyMaker” foot powered pump (right)
- Too much water is not a good solution
  - Nutrient runoff, soil runoff, salinity, etc.

Source: ApproTEC (now Kickstart)

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Rice

- Productivity (UNCTAD, 2003)
  - World average ~3.9 tons/ha
  - National maximum productivity: nearly 9.5 tons/ha in intensive irrigated systems (Australia)
  - National minimum productivity: ~0.75 tons/ha in traditional upland rice systems (Congo Republic)
- Different systems (rainfed lowland, upland, or irrigated) require different levels of inputs and have different yields

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Technology for Rice Farming

- Traditional rice farming
  - o Labor intensive (~300 hrs/acre)
- Mechanized rice farming (e.g., California)
  - o ~4 hrs/acre
- Laser soil leveling
  - o Since late 1970s in California
  - o 0 to 0.5% grade (within 2” ideally)
    - – (Varies if rice only vs. crop rotation; latter requires small grade)
  - o Impacts water requirements, productivity, growth of weeds, etc.
  - o Can be linked to contoured grading

Input Calculations for Rice

- Rice seed
- Sunlight – Free
- Fertilizer – depends on soil conditions
  - Not in widespread use in developing countries
- Pesticides
  - Limited use
- Water – Extensive requirements
  - Most systems rely on submerging the germinated crop (often transplanted after germination elsewhere)
  - Rule of Thumb: One ton of rice requires 2,000 tons of water (!)

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Water for Rice (calculations)

- Assume
  - o 2 tons/hectare yield [1-3 is a safe range]
  - o 4000 tons water required (relatively efficient for developing countries)
    - – Correlated with yield
- Energy requirements
  - o How deep is the water? [100m is not uncommon]
  - o Is it all from irrigation? [Varies by region]
  - o What is the efficiency of pumping? [20% is the norm, instead of the 30-45% possible]

Rice Input Calculations (cont.)

- Physics:
  - o Energy = m*g*h
  - o At 20% efficiency, each hectare requires over 5,500 kWh of electricity per hectare (assumptions from prev. page)
    - – *This is not the average, but applicable for some areas*
  - o That same electricity might cost $350+ if all is from this underground irrigation (full cost accounting, excluding subsidies)
  - o Value of this produce?
    - – 2 tons rice in India had (2005) a Minimum Support Price of $260 (@~130$/ton)
    - – Implications?
      - • Subsidies required
      - • Don’t grow rice on such a location(!)

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Other Modern Technologies

- Proven
  - Soil maps
  - Remote sensing (satellite images)
  - Geographic Information Systems (GIS)
- Under development
  - Expert systems – improving decision making
  - Precision Farming (extending drip irrigation)
    - Sensor Networks
    - Fertigation
  - Biotechnology (GMOs)

Impacts of Technology - Productivity

Farming System / Input Level	Ha/person required to feed
Shifting cultivation	2.65
Low traditional	1.20
Moderate traditional	0.60
Improved traditional	0.17
Moderate technological	0.11
High technological	0.08
Special technological	0.05

Source: Lal (2003)

Other Issues

- Equity
  - Efficient need not equitable
  - Can we incentive (rather than force) people to *not* farm?
- Distribution
  - Reduction of starvation is less about growing more food than making it available
  - Spoilage of food (esp. during storage/transport) is a major issue
- Subsidies and Incentives
  - Changes in cropping
  - Changes in demand (diet)
    - Indirect consumption increases, e.g., Corn in the US
  - Distort global productions and competitiveness
    - Numerous examples
      - Why grow sugarcane in Florida?
      - Rice in US/Australia – est. 0.02% GDP using 7% of the water
        - Inequities in water use get worse when we consider meat vs. grains
    - Overseas Development Assistance << agro-subsidies

Other Issues (cont.)

- Lack of social/economic support systems
  - Social Security
  - Insurance
- Financing issues
  - End-users lack capital for even very small investments
- Innovation
  - Consultative Group on International Agricultural Research (CGIAR)
    - Established in the 1970s
    - Unique in terms of Technology and Development collaborative effort
  - Genetically Modified Organisms (GMOs) and advanced biotechnology?

Supply-chain and optimization

- Price discovery
  - Use of SMS for sharing information (or even calls)
    - Fishermen in Kerala (India)
    - Kenya Agricultural Commodity Exchange (KACE)
    - E-Choupal
    - *Is SMS (texting) technology an open platform?*
- Weather information – short and long-term

Organic, "Green" and Alternative Farming

- Consumers may be willing to pay a premium
  - E.g., Fair Trade Coffee
- Issues of labeling, monitoring, access to markets, etc.

E-Choupal (Discussion)

- What is it?
- Technology Details
- Design
- Why it works?
- Can it be replicated?

Power

Connectivity

e-Choupal System

Training

Content

Transaction Costs

The Mandi Chain

		Rs per MT
Farmer Incurs	Trolley Freight to Mandi = 100 Filling & Weighing Labour = 70 Labour Khadi Karai = 50 Handling Loss = 50	**270**
Processor Incurs	Commission to Agent = 100 Cost of Gunny Bags (net) = 75 Labour (Stitching, Loading)= 35 Labour at Factory (Unload) = 35 Freight to Factory = 250 Transit Losses = 10	**505**
Total Chain		**775**

Source: ITC

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Transaction Costs

The eChoupal Chain

Rs per MT

Farmer Incurs

~~Trolley Freight to Mandi = 100~~
~~Filling & Weighing Labour = 70~~
~~Labour Khadi Karai = 50~~
~~Handling Loss = 50~~

~~**270**~~

Sanchalak 50

Processor Incurs

Commission to ~~Agent~~ = ~~100~~
~~Cost of Gunny Bags (net) = 75~~
~~Labour (Stitching, Loading)= 35~~
Labour at Factory (Unload) = 35
Freight to Factory 100 = ~~250~~
~~Transit Losses = 10~~

~~**505**~~ **185**

Total Chain ~~**775**~~ **185**

Source: ITC

The e-Choupal System

1. ICT Infrastructure:
   a. Computer
   b. Internet
   c. Multimedia
   d. Broadband
   e. Smart Card
   f. VSAT
   g. Solar Power
2. Physical Reach:
   a. Choupals within walking distance
   b. Multipurpose Warehouse hubs within driving distance
3. Key Intermediaries:
   a. Sanchalak (1 per cluster of 5-6 villages) 1500/state
   b. Sanyojak (1 per group of 10-15 choupals) 100/state
   c. ITC (support the farm produce marketing end)

e-Choupal

- Technologies were largely off the shelf
- Information was free to farmer
  - ITC and Sanchalak only make money if he/she chooses to transact
- Trust was a key ingredient to the success of e-Choupal
- Information is only one ingredient – ITC provided the supply chain to actually fulfill the transaction (warehouses nearby)
- Extending the infrastructure for other uses