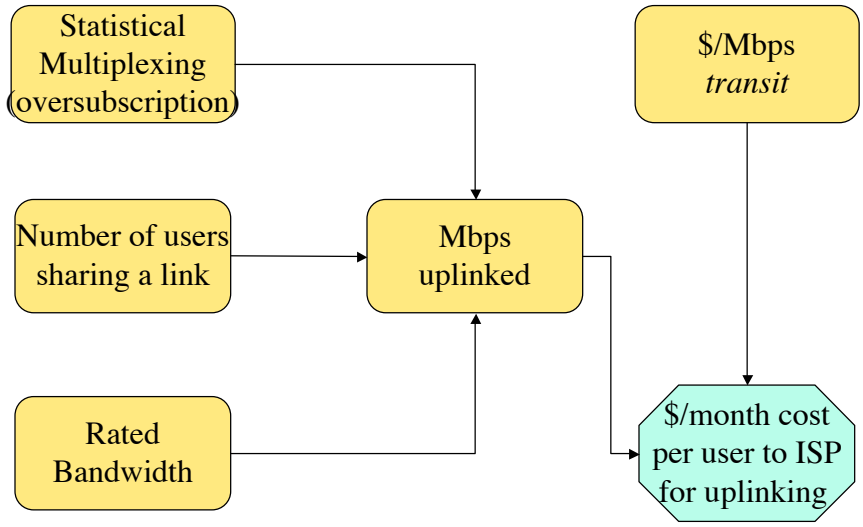
ICT and Development

Week 10 – March 28 - 30

Components of Connectivity

Hardware / Installation	Marketing / Advertising	O&M		Uplinking (transit fees)
		CRM	Technical	
• One-time capital costs are amortized over time • Cost depends on: - Interest rates - Churn - Re-usability of components	• One time costs • Depends on competition	• Also depends on competition	• Varies by technology	• Vary by location • Oversubscription ratios are an ISP choice • Speeds offered determine what applications can be run

What does it Cost to use up Bandwidth?



Different Bits are Different

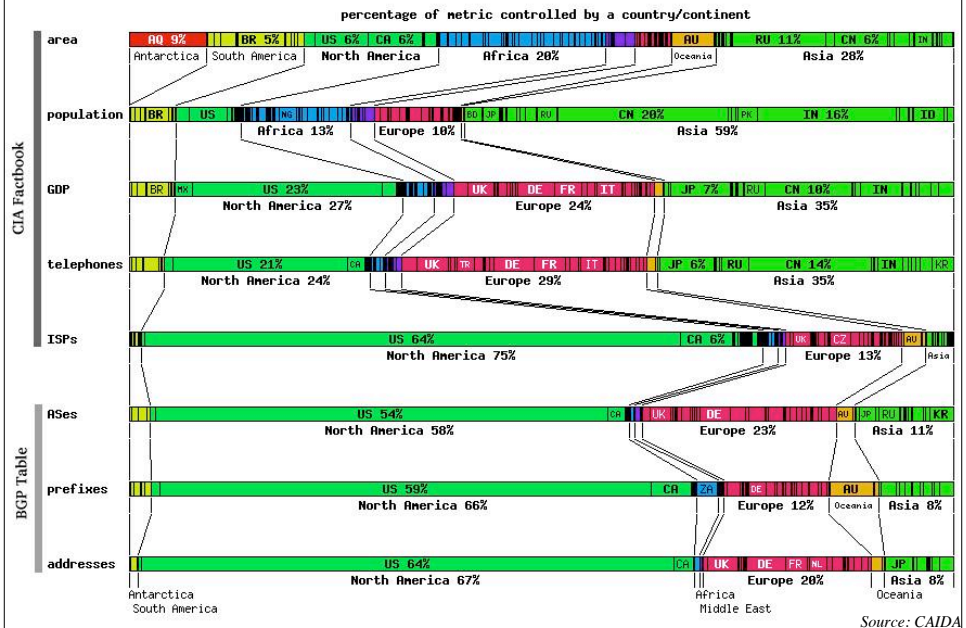
p$ = picodollars = 10^{-12}

2002 or 2003 US Statistical Abstract Average Numbers except in *Italics*

- Voice
  - Fixed
    - 23 $/month, 1 month/*1923* min. → ~ 3,100 p$/bit
  - LD
    - *$0.10/minute* → 26,000 p$/bit
      - Incl. International charges (FCC numbers)
- Web (broadband user)
  - *35 $/month, 2 hours per day usage, 30 kbps average usage* → ~ 5,400 p$/bit
- TV (cable/satellite, excl. PPV)
  - 225 $/year/person, 2.58 persons/household, 850 hours/year watched → ~ 36 p$/bit
  - A good fraction of their revenues comes from advertising
  - *BUT, we don't know what demand will look from 5 years from now, or, say, under 100 Mbps conditions*

Thinking Globally…

Digital Divide



Source: CAIDA

What is the Digital Divide?

"Digital Divides are not just the result of economic differences in access to technologies (*Have's* vs. *Have-Not's*), but also in cultural capacity and political will to apply these technologies for development impact (*Do's* vs. *Do- Not's*)."

– Markle Foundation Report (2003)

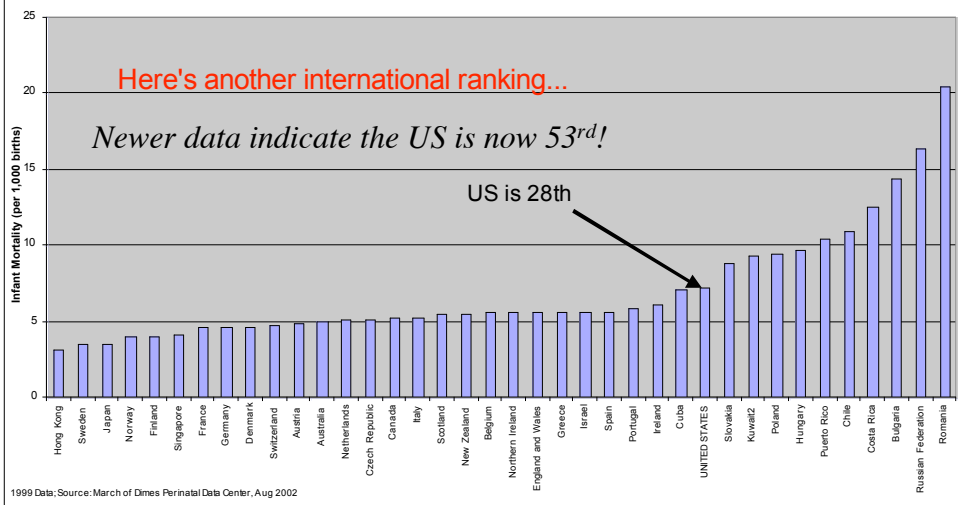
What is the Digital Divide?

- The divide is a manifestation of underlying divides, a symptom rather than a cause
  - Economic, social, gender, age, geographic, etc. divides
- It is a moving target
  - Dial-up, broadband, "real broadband", etc.
- Information fuels the present (Knowledge) Revolution
  - Enables the Drivers of Growth

Access → Information → Knowledge → Opportunity

There are other Metrics and Divides

US may rank 19th in broadband (2005), but…



1999 Data; Source: March of Dimes Perinatal Data Center, Aug 2002

4 Dimensions of the Digital Divide

- Awareness
  - What is it, and what can one do with it?
- Availability
  - Is it offered to me?
- Accessibility
  - Can I realistically use it (including issues of literacy and language)?
- Affordability
  - Globally, ICT is 6.6% of GDP (telecom, hardware, and software)
  - What percentage of income does access cost worldwide?

Improvements are needed in all Dimensions of ICT

- Computers
  - Life cycle analyses
  - Interface
- Connectivity
  - Broadband?
- Content
  - Locally relevant information
- (human) Capacity
  - Literacy
  - e-Literacy

Why is Connectivity so Expensive in Developing Countries?

- Issues of scale – few users
- International Gateway bottlenecks
- Licensing fees and duties
- Monopoly carrier (de-facto, often)
- Poor design
- And many more reasons…

Mobile Phones

- Dominant connectivity in much of the world
- ~10% penetration in Africa!
- Largest market in the world today is…?
- BUT, the Avg. Rev. Per User (ARPU) can be high (=expensive)
  - Africa (2004) $28
  - India was only $11 (and under $8 today)
- Do mobiles have data capabilities?

$100 Laptop – Pros and Cons

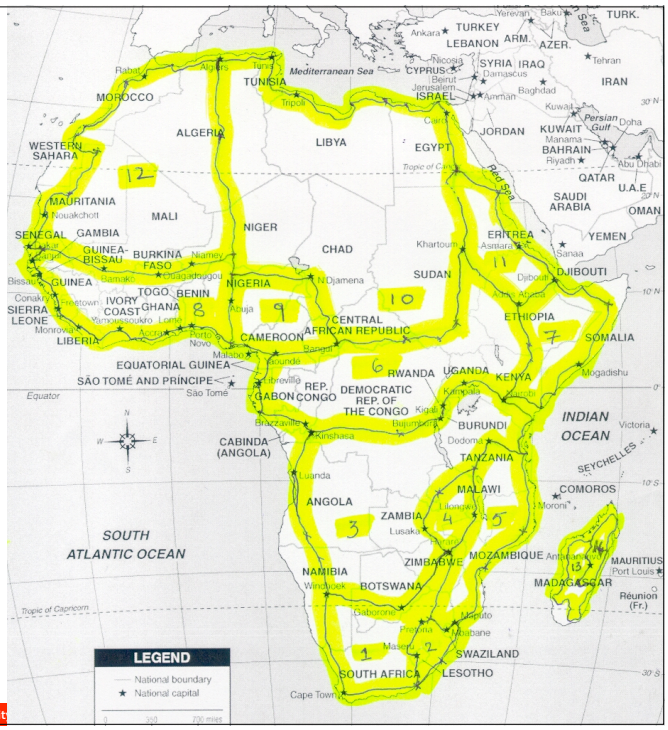
- Pros
  - Creates awareness
  - Might have some innovation
  - In some cases, may fulfill a latent *need*
- Cons
  - Top-down
  - Robustness unknown
  - Energy
  - Connectivity
  - Won't share easily
  - Buy-in is expensive
  - Content?
  - Role of teachers

Idea: FiberAfrica Concept

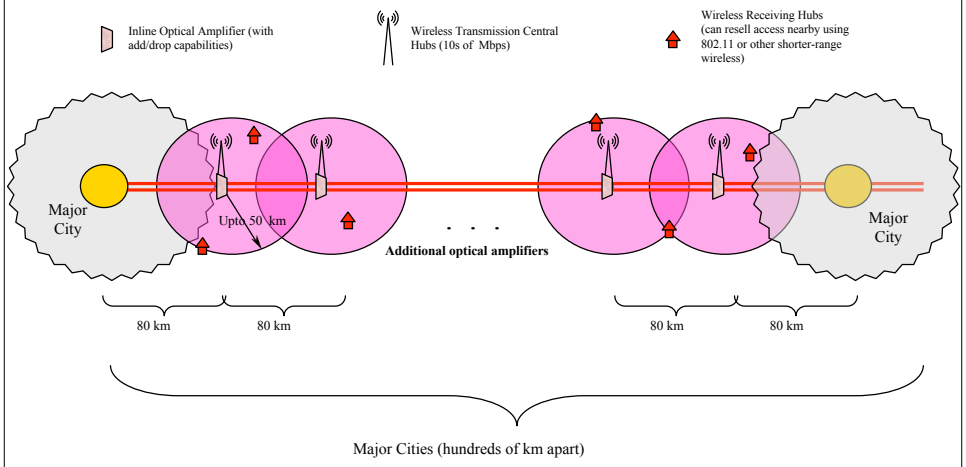
- A revolutionary design to provide the majority of the population nearby access to broadband for a one-time capital expenditure of ~$1/capita
  - Can be cheaper by harnessing any existing infrastructure
  - Includes optical fiber of virtually unlimited capacity between major population centers, *and* broadband wireless hubs for wide-spread access over large areas
    - Excludes PCs and end-user equipment
- Revolutionary business model could allow virtually free access to schools, hospitals and rural community centers

FiberAfrica Backbone Network

- Almost 70,000 km core backbone (shown)
  - DWDM Technology for scalability and cost-effectiveness
- 35,000 km fiber spurs (not shown)
- Routing chosen to provide maximum coverage
  - Can leverage existing fibers and rights of way (along highways



FiberAfrica Design



Detailed design undertaken, for all capital and operating expenses

Business Model(s)

- Many options available, but requirements include
  - Operational costs must be covered
    - Our calculations show it can be done, affordably
  - Capital costs can be grant-based (only ~$1B)
  - There must be end-user and community empowerment
  - Public core, competitive edge
- Won't create a new government (or other) bureaucracy
  - Consortium or partnership models have worked, e.g., IntelSat
  - Allows role for AfricaUnion/NEPAD as appropriate
  - Maintains individual governmental sovereignty

Why This Model?

- Appropriate scale – into the rural areas
- Optical fibers make it "future-proof"
  - One time cost leads to fiber infrastructure that can last decades
  - Capital costs of fiber much lower than conventional wisdom
    - Few thousand $/km maximum
- Increases access and domestic usage – not addressed merely by having an international fiber link (e.g., EASSY proposal)
  - "Closed Club" arrangements of such fiber systems make them unaffordable
- Business model is sustainable
  - Public-Private partnership
  - Synergistic with mobile providers – who lack such capacity for broadband
  - Almost no barrier to entry for casual users (through schools and community access points)

Open Access / FiberAfrica Underpinnings

- Overcoming the infrastructure disconnect
  - Fiber lasts 30+ years, electronics need to be amortized in 5-7 years
    - Today, carriers often charge more (short-term business models)
    - Higher cost models are inherently a niche solution
- No conflict with competition
  - Focus on rural and "uneconomic" areas
  - ISPs would also benefit
- Can justify "special regulation" only for the public good
  - Could also attract grants and soft loans

More info on FiberAfrica

For more information, see:

http://www.contrib.andrew.cmu.edu/~tongia/FiberAfrica--ending_a_digital_divide.pdf

OR

http://tinyurl.com/dttga

ICT and Development

- Also called ICT for Development
- "ICT4D"

Development in Context

- 50-60 years ago, the world was VERY different
  - Much of the world was not independent
  - Much lower population
  - Much greater disparities
    - Urban/rural
    - By ethnicity or sub-group
    - Limited granular data

Development Trajectories

- Post WWII
  - Intl. Agencies + the state = big development
  - Rapid industrialization, e.g., Japan/USSR
- 1960s/70s
  - State guiding the economy to the provision of "basic needs"
  - Lots of "appropriate technology" ideas
- 1980s
  - State is incompetent, let markets take care of things
  - Economies liberalize

Development Trajectories (cont.)

- 1990s
  - Markets are central
  - BUT liberalization/globalization may bypass the poorest, so need civil society to increase "participation"
  - USSR falls apart, liberalization accelerates
- 2000s
  - Market to the poorest: consumer = citizen.
  - IT is everywhere.
  - State must be guarantor of private interests
- China did something similar, but with a delay

Where did (does) Technology Fit In?

- Incremental changes within processes
- Changes to processes within economy (e.g., Services/Knowledge Economy)
- ICT
  - Large investments and growth
- Infrastructure buildout
  - What were large US buildouts? When? By Whom?

Lags and leapfrogs

- Internet
  - Broadband
  - Integration with mobile
- Mobile Phones
- Public Transport
- Community based healthcare (Latin America)

Internet - Innovation at the Edge

- Some innovation is expensive
  - Pharmaceuticals
  - Chip design (and building)
- Some innovation can be done in the archetypal "garage" or with limited resources
  - Firefox
  - Podcasts
  - GIS Mashups (e.g., Google maps + Craigs List)
  - Street theaters and songs for HIV education
- The Internet by design is meant to allow innovation at the edge
  - Dumb cloud in the middle

Next Generation: "Fundamental" breakthroughs

- Genomics
- Nanotechnology
- Artificial Intelligence
- Optical Computing
- Quantum Computing
- Energy
  - Solar, Fusion, Carbon/Hydrogen
- ???

Disconnects

- What is the greater challenge?
  - Feeding 12 billion
  - Or, gainful employment for the 12 billion so they can afford basic human services?
- How can sustainability be captured into "markets"?
  - Markets are excellent vehicle for fostering efficiency within appropriate price signals
    - Externality issues
    - We may still not like the outcome

Value of Knowledge and Technology

- Services Sector growth rates > Manufacturing > Agriculture (GDP basis)
- Every "commodity" exporter has seen low development
  - Congo
  - Nigeria, Middle East
  - Russia/USSR
  - What of China?

Knowledge is *the* source of growth and wealth creation

- Asymmetric growth is inevitable
- Pockets of success need to be identified, internalized, and replicated
- Innovations *around* technology can have profound impacts
  - E.g., prepaid for mobile phones
- Technology and knowledge don't achieve the Millennium Development Goals (MDGs); they *help* achieve the MDGs

ICT4D - Scholarly Work

- Earlier, was segmented by domain
  - Developmental Economics
  - Energy, Healthcare, etc.
  - IT
- Newly emerging field of ICT and Development
  - Nascent
  - Many "events" are not rigorous (e.g., WSIS)
    - Lack of metrics is a serious challenge
    - ICTD2006 we are organizing is an attempt
    - WWW2006 now has an emerging regions track
  - A few journals are there (e.g., ITID)

Studying ICT4D

- Nascent discipline
  - High visibility, e.g., WSIS – World Summit on the Information Society
    - Lots of good intentions
    - Lots of Hype
- More questions than answers…
  - Does technology exacerbate or mitigate existing divides (gender, age, rural/urban, etc.)?
  - Are cell-phones the answer to the digital divide?
  - How to we manage universal service for connectivity?
  - Are sensors for water cost-effective for agriculture?
- Can be approached from many perspectives (disciplines), using many tools
- Must be rigorous, scientific, and, hopefully, meaningful
  - Basic AND applied research

Field Work

- Theory vs. Practice
  - "In theory there is no difference between theory and practice. But, in practice, there is"

    – Jan L.A. van de Snepscheut
- Remember Carlos Braga's 4 Lessons:
  - Elvis, Einstein/Beethoven, Mother Teresa, and Sex…

Student Activities

- TechBridgeWorld
  - V-Unit
  - STEP
  - Other
- SURG
- CANA

Community Networks

- Many communities without broadband are setting up their own networks
  - Wired (Fiber) based – allows any and all services
    - Greenfield digs
    - Poletop (existing infrastructure)
  - Wireless
    - Wireless mesh networks
    - Fixed Broadband Wireless (WiFi, non-Wifi)
- Utopia network in Utah
  - Open Access network
  - Public infrastructure, private (competitive) retail services
  - Has led to the "Walmart Effect"
- Why aren't there more community networks?

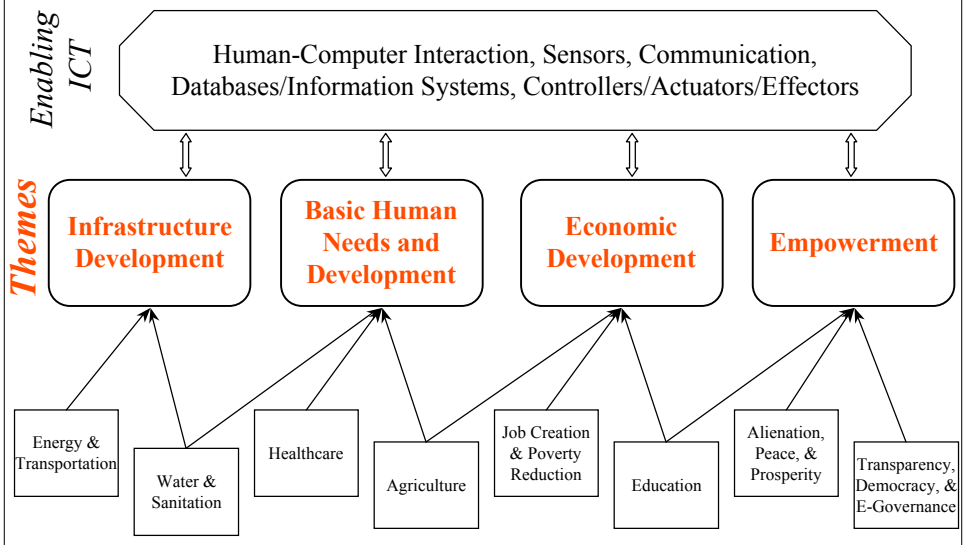
ICT as an Enabling Technology

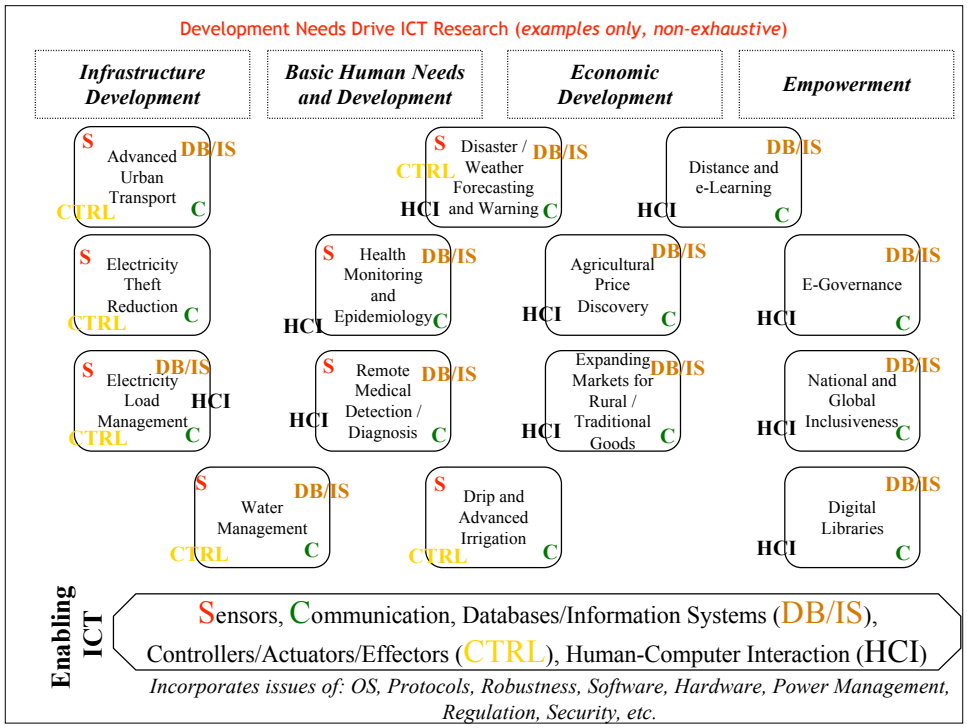
- Information and Communications Technology (ICT) is an all-purpose technology
- The growth of ICT technology – bandwidth, computational speed and storage – is spectacular
- Leap-frogging technologies do not demand a large or preexisting resource base
- Successful applications have emerged but remain largely untapped for sustainable development

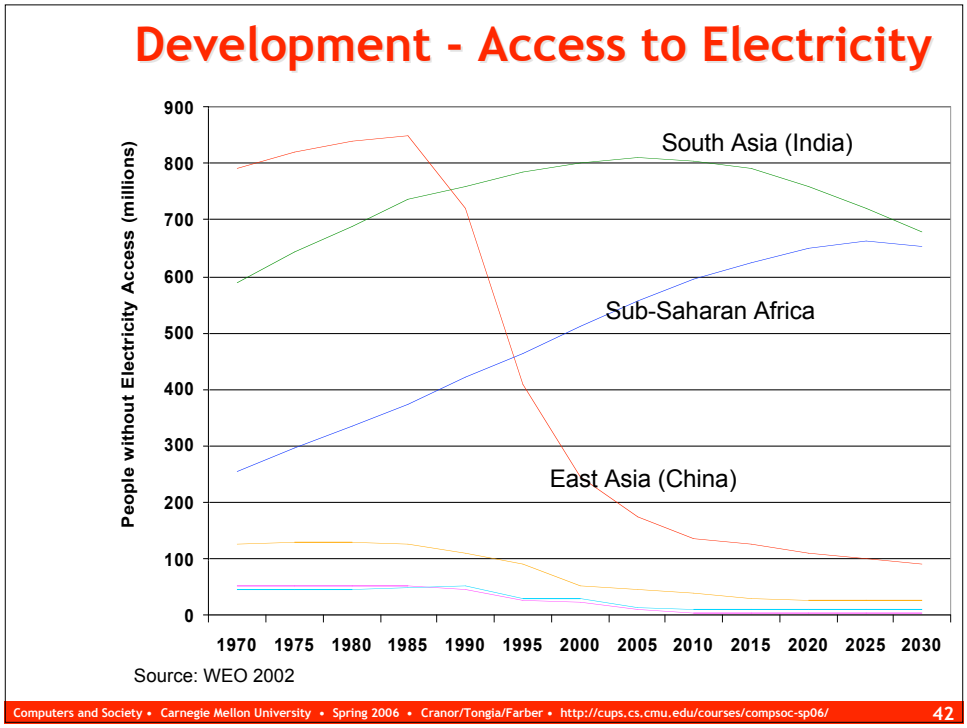
The Vision

- ICT is not the cure-all to the world's problems
- *But* it can be a powerful tool to facilitate and enable affordable solutions for
  - Infrastructure Development
  - Basic Human Needs and Development
  - Economic Development
  - Empowerment
- However, appropriate ICT is not yet available for many Sustainable Development needs

ICT and Development




Development Needs Drive ICT Research (examples only, non-exhaustive)
Infrastructure Development
Basic Human Needs and Development
Economic Development
Empowerment
Advanced Urban Transport
Disaster / Weather Forecasting and Warning
Distance and e-Learning
Electricity Theft Reduction
Health Monitoring and Epidemiology
Agricultural Price Discovery
E-Governance
Electricity Load Management
Remote Medical Detection / Diagnosis
Expanding Markets for Rural / Traditional Goods
National and Global Inclusiveness
Water Management
Drip and Advanced Irrigation
Digital Libraries
Enabling ICT
Sensors, Communication, Databases/Information Systems (DB/IS), Controllers/Actuators/Effectors (CTRL), Human-Computer Interaction (HCI)
Incorporates issues of: OS, Protocols, Robustness, Software, Hardware, Power Management, Regulation, Security, etc.


Development - Access to Electricity
People without Electricity Access (millions)
900
800
700
600
500
400
300
200
100
0
South Asia (India)
Sub-Saharan Africa
East Asia (China)
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030
Source: WEO 2002
Computers and Society • Carnegie Mellon University • Spring 2006 • Cranor/Tongia/Farber • http://cups.cs.cmu.edu/courses/compsoc-sp06/
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How to achieve development?

- China provides a number of insights
  - Limited Democracy
  - Central Control with increasing autonomy to provinces and local authorities
  - Economic growth was probably KEY
  - LDC issue - State Owned Enterprises
    - Inefficiency
    - Corruption
    - Poor allocation of capital and resources
    - Limited understanding of technology
      - Policies
      - Education / Investment
      - Tendering

Is it Technology?

- Government matters
  - Till a few decades ago, many countries were colonies
- What matters is how technology is integrated into society
  - WHO is able to benefit
- Land reforms were key to development

Free Rider Effects

- Are traditional economic measures enough?
- Externalities
  - Critical issue if ICT is more a means than an end
  - Mid-day Meal Program in India example
- Public Goods
- Network Effects

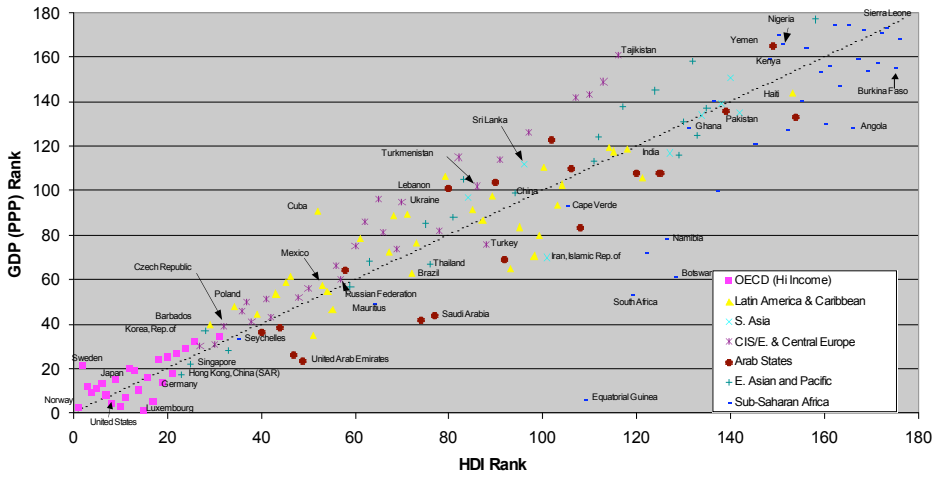
Measuring Development

- GDP has often been used to measure progress
  - Limitations?
- What other attributes would we want to compare?
  - Ordinal vs. cardinal
  - Time series
    - Discounting challenges, especially inter-generational

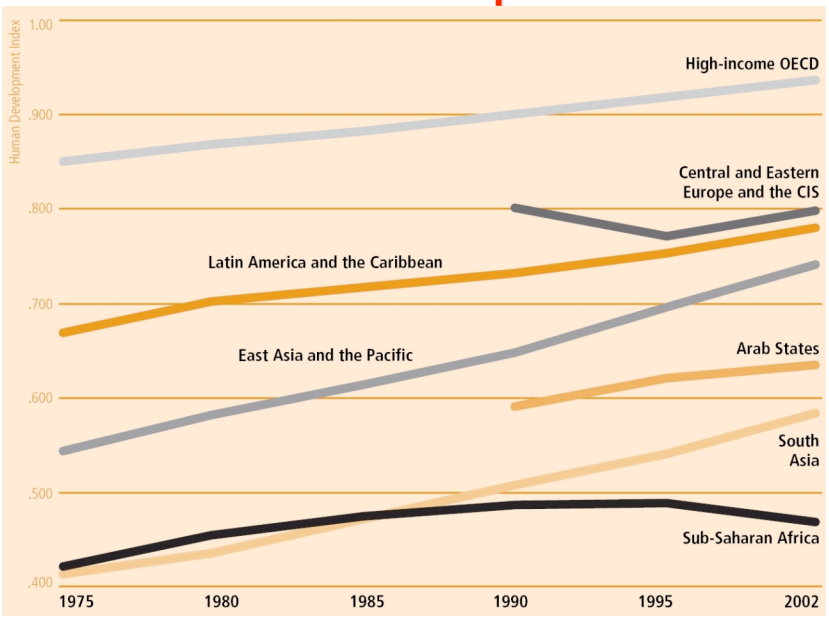
Human Development Index (UNDP)

- A long and healthy life
  - Life expectancy at birth
- Knowledge
  - Adult literacy rate
  - Combined gross enrolment ratio for primary, secondary, and tertiary schools
- Decent Standard of living
  - GDP per capita (PPP US$)

GDP vs. HDI (Ranks)



Human Development Indices



Source: UNDP Human Development Report 2004

HDI Over Time

(UNDP Animation)

The Imperative

- Developing countries are starved of resources for human development
- Developing nations are poor; around 2.5 billion people earn less than $2 a day*
- The infrastructure is inadequate or unavailable
- Technologies to overcome these deprivations are often unknown, untested or not deployed in the developing world

*PPP

Source: Millennium Development Goals, UN Human Development Indicators

Millennium Development Goals

"We will spare no effort to free our fellow men, women, and children from the abject and dehumanizing conditions of extreme poverty, to which more than one billion of them are currently has subjected."

United Nations Millennium declaration – September 2000

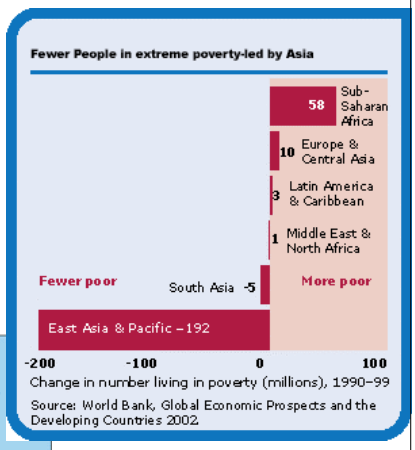
MDG (cont.)

- Eradicate extreme poverty and hunger
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Combat HIV/AIDS, malaria, and other diseases
- Ensure environmental sustainability
- Develop a global partnership for development

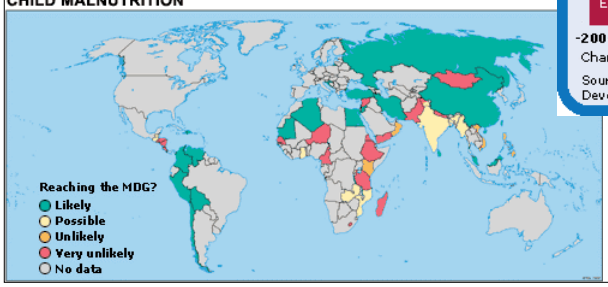
Extreme Poverty and Hunger

Halve the proportion of people living on less than one dollar per day in low and middle income economies, between 1990 and 2015 – from 29% to 14.5%

- In the 1990s, global poverty rates fell 20%, but growth was uneven
  - Sub-Saharan Africa saw a slight increase
  - Europe and Central Asia solve a substantial increase (in relative terms)



CHILD MALNUTRITION

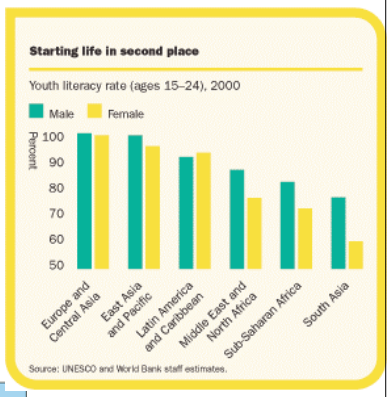


Source: MDG

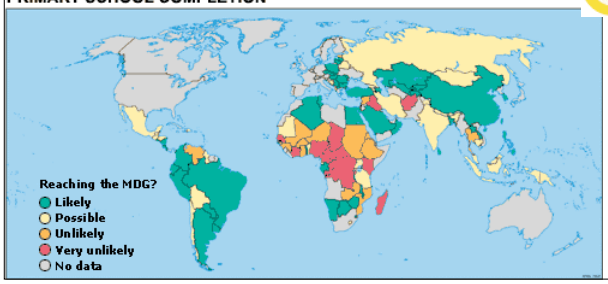
Universal Primary Education

Ensure that all children will be able to complete primary schooling, by 2015

- In 1999, 120 million primary school age children were not in the school
  - 53% were girls
  - 74% were in South Asia and sub-Saharan Africa
- MDG reset the earlier targets from 2000 to 2015



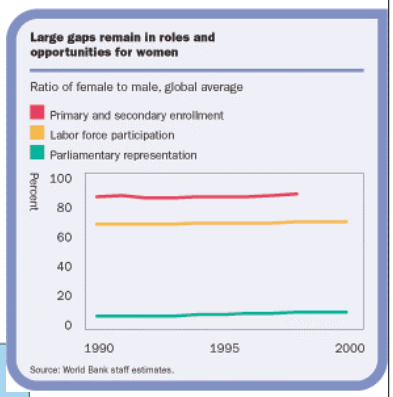
PRIMARY SCHOOL COMPLETION



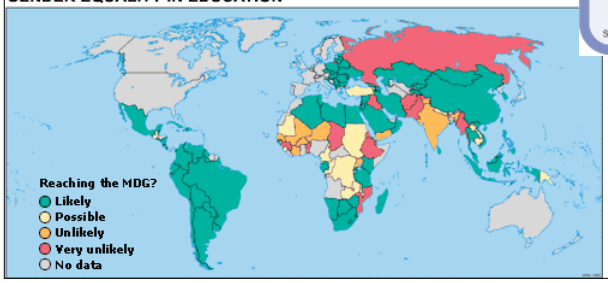
Source: MDG

Gender Equality and Empowering Women

Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015



GENDER EQUALITY IN EDUCATION

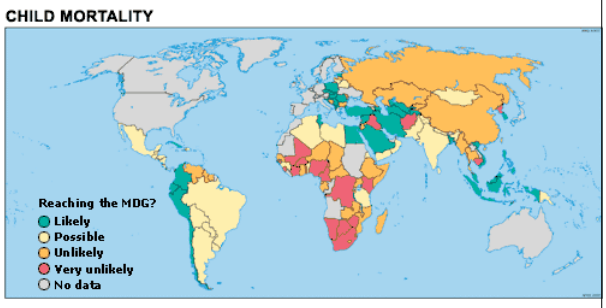


Source: MDG

Reduce Child Mortality

Reduce by two thirds and be under – five mortality rate, between 1990 and 2015

- Deaths of children under five fell from 15m to 11m over the eighties.
  - Vaccination programs
  - Oral rehydration therapy
  - Antibiotics
  - Economic growth and improved social conditions

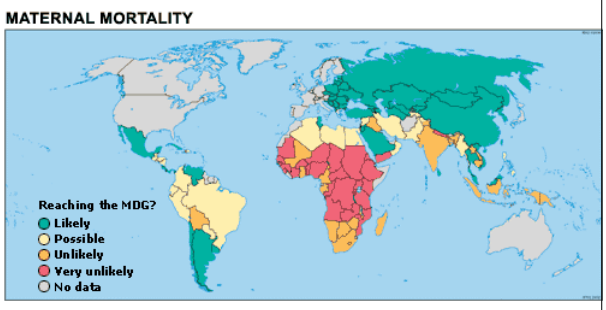


Source: MDG

Improve Maternal Health

Reduce by three quarters the maternal mortality ratio, between 1990 and 2015

- Women's health
- Access to medical services, especially during childbirth



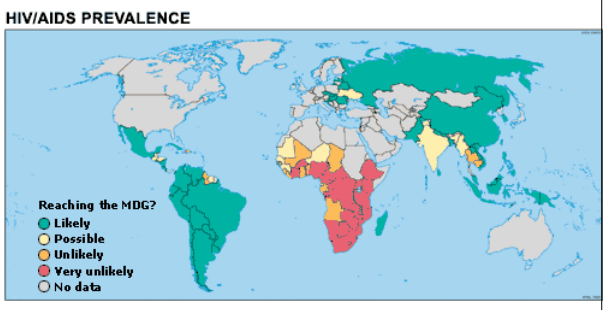
Source: MDG

Combat HIV/AIDS, Malaria and other Diseases

Halt and begin to reverse the spread of HIV/AIDS by 2015

Halt and begin to reverse that incidence of malaria and other major diseases by 2015

- HIV
  - Tremendous impact on sub-Saharan Africa
    - Some countries have adult infection rates over 30%
  - HIV affects young people disproportionately – half of new infections are among 15 to 24-year-olds



Source: MDG

Insure Environmental Sustainability

Integrate the principles of sustainable development into country policies and programs and reverse the losses of environmental resources

Halve the proportion of people without sustainable access to safe drinking water, by 2015

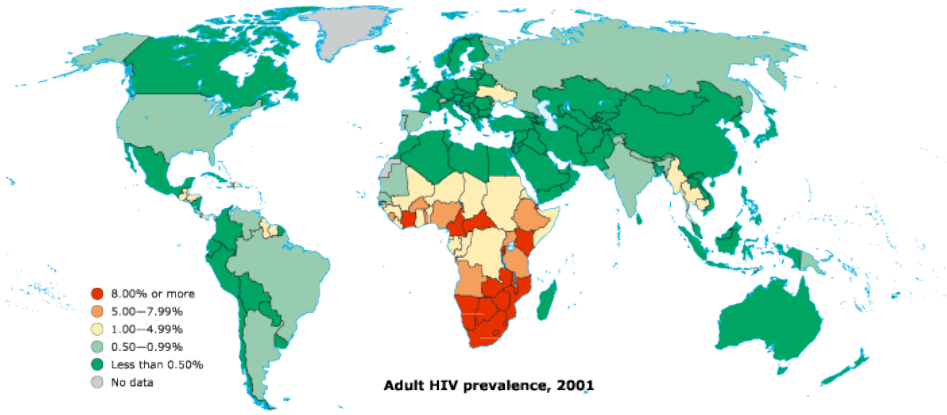
Achieve by 2020 a significant improvement in the lives of at least 100 million slum dwellers

Source: MDG

Build a Global Partnership for Development

- Kofi Annan's Global Compact – public and private partnerships
- Need more than aid
  - Not all aid goes to the poor
  - Average value of aid to low-income economies was $12 a person in 2000
- Trade barriers (and subsidies) are significant
- Reducing debt levels for the Heavily indebted poor countries (HIPC)

The Daunting Task - HIV/AIDS



Source: MDGs/WorldBank

What's Missing (?)

- Energy
  - UNDP's 2005 Report (The Sustainable Difference: Energy and Environment to Achieve the MDGs) recognizes this
- ICT
  - Sector is doing very well…
    - Why?
  - "Bread vs. Computers?"
- Other Infrastructure

MDGs Progress Report

- Millennium +5 Conference in Sept. 2005 will review the MDGs
- Wide variance in targets, and by country

Table 1
Major trends in the Goals, by region

	Africa		Asia				Oceania	Latin America & Caribbean	Commonwealth of Independent States	
	Northern	Sub-Saharan	Eastern	South-eastern	Southern	Western			Europe	Asia
Goal 1 Eradicate extreme poverty and hunger										
Reduce extreme poverty by half	on track	high, no change	met	on track	on track	increasing	no data	low, minimal improvement	increasing	increasing
Reduce hunger by half	high, no change	very high, little change	progress but lagging	progress but lagging	progress but lagging	increasing	moderate, no change	on track	low, no change	increasing
Goal 2 Achieve universal primary education										
Universal primary schooling	on track	progress but lagging	on track	lagging	progress but lagging	high but no change	progress but lagging	on track	declining	on track
Goal 3 Promote gender equality and empower women										
Girls' equal enrollment in primary school	on track	progress but lagging	met	on track	progress but lagging	progress but lagging	on track	on track	met	on track
Girls' equal enrollment in secondary school	met	progress but lagging	no data	met	progress but lagging	little change	progress but lagging	on track	met	met
Literacy parity between young women and men	lagging	lagging	met	met	lagging	lagging	lagging	met	met	met
Women's equal representation in national parliaments	progress but lagging	progress but lagging	declining	progress but lagging	very low, some progress	very low, no change	progress but lagging	progress but lagging	recent progress	declining
Goal 4 Reduce child mortality										
Reduce mortality of under-five-year-olds by two-thirds	on track	very high, no change	progress but lagging	on track	progress but lagging	moderate, no change	moderate, no change	on track	low, no change	increasing
Measles immunization	met	low, no change	no data	on track	progress but lagging	on track	declining	met	met	met
Goal 5 Improve maternal health										
Reduce maternal mortality by three-quarters	moderate	very high	low	high	very high	moderate	high	moderate	low	low
Goal 6 Combat HIV/AIDS, malaria, and other diseases										
Halt and reverse spread of HIV/AIDS	no data	stable	increasing	stable	increasing	no data	increasing	stable	increasing	increasing
Halt and reverse spread of malaria	low	high	moderate	moderate	moderate	low	low	moderate	low	low
Halt and reverse spread of TB	low, declining	high, increasing	moderate, declining	high, declining	high, declining	low, declining	high, increasing	low, declining	moderate, increasing	moderate, increasing
Goal 7 Ensure environmental sustainability										
Reverse loss of forests	less than 1% forest	declining	met	declining	small decline	less than 1% forest	declining	declining except Caribbean	met	met
Halve proportion without improved drinking water in urban areas	met	no change	declining access	high access, no change	met	met	high access, no change	met	met	met
Halve proportion without improved drinking water in rural areas	high access, little change	progress but lagging	progress but lagging	progress but lagging	on track	progress but lagging	low access, no change	progress but lagging	high access, limited change	high access, limited change
Halve proportion without sanitation in urban areas	on track	low access, no change	progress but lagging	on track	on track	met	high access, no change	high access, no change	high access, no change	high access, no change
Halve proportion without sanitation in rural areas	progress but lagging	no change	progress but lagging	progress but lagging	progress but lagging	no change	no change	progress but lagging	little change	little change
Improve the lives of slum dwellers	on track	rising numbers	progress but lagging	on track	some progress	rising numbers	no data	progress but lagging	low but no change	low but no change
Goal 8 A global partnership for development										
Youth unemployment	high, no change	high, no change	low, increasing	rapidly increasing	low, increasing	high, increasing	low, increasing	increasing	low, rapidly increasing	low, rapidly increasing

met or on track | progress, but too slow | no or negative change | no data

MDGs Review

Source: UNDESA 2004

Change…Stakeholder Responsibilities

- Governments
- Official Foreign Assistance (ODA)
  - Charity
  - Is a new "Marshall Plan" feasible?
- Is there a debt trap?
- Public vs. Private investments
  - Issues of regulation
- Exit strategies

Successful Development

- Sustainable
- Institution and capacity building
- Stakeholder participation
- Empowerment
- Feedback and flexibility
  - Transparent metrics