Development Engineering

CSEP 590 B
Engineering the Immunization Cold Chain
Richard Anderson

Today

- Announcements
- Some general themes
- Mapping the immunization cold chain
- Discussion of Uganda deployment

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Announcements

- Discussion Sections – Zoom – Attend one
  - Wednesday: 3:00-4:00 pm
  - Wednesday: 5:00-6:00 pm

- Homework 1, Due April 13.
  - Submit by email
  - Course grade based on 7 of 9 assignments
  - Defer questions on HW1 until end of class

- Reading: Global Goods Software for the Immunization Cold Chain, W. Brunette, R. Anderson, et al., Under submission.

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Course Schedule

Date	Topic	Lead
April 6	Engineering the Vaccine Cold Chain	
April 13	Community Cellular Networks	Kurtis Heimerl
April 20	Remote Temperature Monitoring	Martin Lukac, Nexleaf
April 27	Election Monitoring	James Long
May 4	Voice Based Social Networks	Aditya Vashistha
May 11	TBD	
May 18	Fintech for Rural Networks	Jenny Aker
May 26	TBD	
June 1	Open Data Kit	Waylon Brunette

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Development Engineering

Technological interventions to improve human and economic conditions in low-resource settings

An engineering discipline aimed at addressing global inequity

Develop principles for design, introduction, scaling, and sustainability of Global Good technology

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Engineering

- Domain Understanding

- General Principles

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Case study approach

- Engage with individual examples

- Extract transferable knowledge

Today – The immunization cold chain

General Issues

- Top down management of global development
- Global Goods software
- Designing for users

Global Development

- Global organizations set policy

- Donors

- Country ministries

Global Goods Software

- Software systems for global development
  - Health data reporting, medical records, human resource management, health insurance, logistics
- Goal of Global Goods software is to have a positive impact
- Generally, Open Source, but different models
  - Many projects depend on donor support
- Projects often have a fairly long history
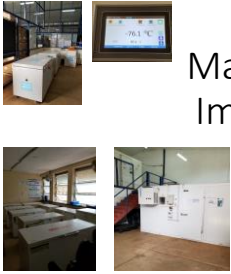 - Barriers to entry

Designing for the user

- Common conflict between "purchaser of system" and user of the system
- Information systems may make overall system more efficient, but the actual users do more work
- In development setting, Global Organizations and Country Ministries set policy and are the "customers"

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Mapping the Global Immunization Cold Chain

Richard Anderson
University of Washington

Problem: How do we count every vaccine refrigerator in the world?

- Mapping the global immunization cold chain
- Construct an accurate cold chain equipment inventory for all low- and medium-income countries

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Why is this an interesting Development Engineering problem?

- Address the problem of taking DevEngr interventions to scale
  - How does the field have impact
  - Difference between pilots and sustainability
  - Examples: 99 Dots, Digital Green, DHIS2
- Understanding "Global Good" Software
  - Creating, deploying, and sustaining low-cost software platforms
  - Open source software in global health eco-system

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Why this is important: Immunization

- One of the world's most effective health intervention
  - Wide coverage of basic vaccines
    - Diphtheria, Pertussis, Tetanus: 77% in poorest countries
    - Tremendous reduction in deaths
    - Some diseases close to elimination

Polio 1990

Polio 2008

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Why this is important: Immunization Logistics

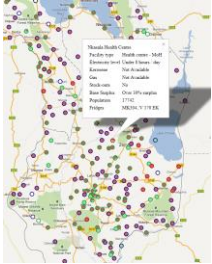- Vaccines need to be kept in a given temperature range
  - Spoil if vaccines freeze
  - Spoil if above 8 degrees for extended period of time
- Facilities must store between 1 to 3 months of stock

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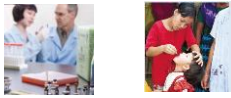

Why this is important

- This information is critical for decision making for managing the global immunization cold chain

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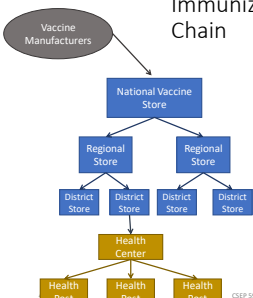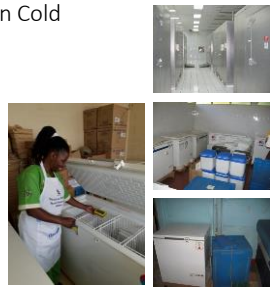
Immunization Domain Background

- Vaccines are the same around the world
- For many countries – immunization is managed and funded globally

UNICEF, GAVI THE GLOBAL ALLIANCE FOR VACCINES & IMMUNIZATION, World Health Organization

Ministry of Health
National Immunization Program
Logistics

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Immunization Cold Chain

Vaccine Manufacturers → National Vaccine Store → Regional Store, Regional Store → District Store, District Store, District Store, District Store → Health Center → Health Post, Health Post, Health Post

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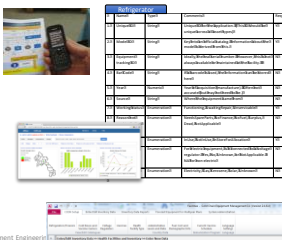## Immunization Cold Chain Challenges

- Ensure that all countries have high quality vaccine cold chains
  - Working equipment at all points in vaccine supply chain
  - Sufficient capacity for vaccines
- Refrigerators need power
  - Grid power, Solar power, Gas, Kerosene
  - Many areas suffer from regular power outages
  - Desire to replace Kerosene / Gas equipment with Solar
- Equipment upgrades
  - Identify needs and determine order size
  - Remove obsolete equipment
  - Ensure proper installation
  - Establish repair infrastructure
  - Monitoring of equipment condition

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My background in immunization logistics

- Sabbatical with PATH (2008-2009)
- CCEM Project
- Country projects: Nicaragua, Kenya, Zimbabwe, Malawi, Nigeria, Ghana, Uganda, India, Pakistan, Laos
- Multiple projects on cold chain information systems
  - DHIS2 for Cold Chain Inventories
  - SMS Temperature Reporting
- Promoted Cold Chain Equipment Inventory Data Standards

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Problem Statement

- Count every refrigerator
- Global data base of refrigerator and health facility info
- Analytics to make this information useful

- Caveats
  - Focus on low and middle income countries
  - Multiple levels of dashboards and distinction between global and country data bases

2010 data	Kenya: 5306 facilities, 4946 refrigerators, Population 41 M
	Malawi: 827 facilities, 1426 refrigerators, Population 15 M
	Uganda: 2846 facilities, 3153 refrigerators, Population 35 M
	Zimbabwe: 1605 facilities, 3080 refrigerators, Population 14 M

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Cold Chain Equipment Inventories

- No accurate global equipment inventories
- Inconsistent at the country level
  - Inventories often become out of date
  - Not updated for equipment changes
  - Health facility information is also a challenge
- Periodic efforts to collect inventory information for reporting
  - Often restricted to sampling
- Fragmented data sources
- Different health systems inside a country
  - Public, Private, NGO, Faith-based

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Vision

Country Cold Chain Information System

Country Cold Chain Information System

Country Cold Chain Information System

Global Cold Chain Information System

BILL & MELINDA GATES foundation
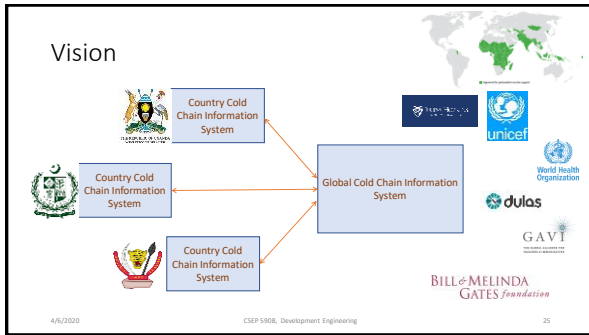
Part I: Visualizing the Cold Chain

- Map based visualization
  - GIS Coords
  - Regions
- Global Management Questions
  - Country summaries
  - Equipment trends
  - Integrated analysis tools and models
- Country Cold Chain Management
  - Equipment management
  - Allocation
  - Reporting

Part II: Data Management

- Cold Chain Equipment Inventory
  - Basic equipment and facility information
  - Tracking of performance and maintenance
- Remote data updates
  - Keeping data up to date is the critical challenge
  - District cold chain supervisor responsible for managing equipment
  - Mobile App is feasible for district supervisors
- Integrate with other Health Information Systems
- Ownership by the country

ODK-X

- Mobile data collection on Android Phones. Project started at University of Washington by Professor Gaetano Borriello
- Open Data Kit 1.0 aka ODK
  - Submission of forms
- Open Data Kit 2.0 aka ODK-X
  - Synchronization with a database
- Open source tools. Strong commitment to contributing to global good software

Cold Chain App

- App built on top of the ODK-X platform
  - Combination of ODK Survey and ODK Tables
  - Written in Java Script
- Manage a database of health facilities and refrigerators associated with facilities

Architecture

Dash Board — Database — Report Generation — Global Cold Chain Information System

ODK-X Client — Local Database

ODK-X Server — Country Database — Azure

ODK-X Client — Local Database

Data Bridge

CCEM
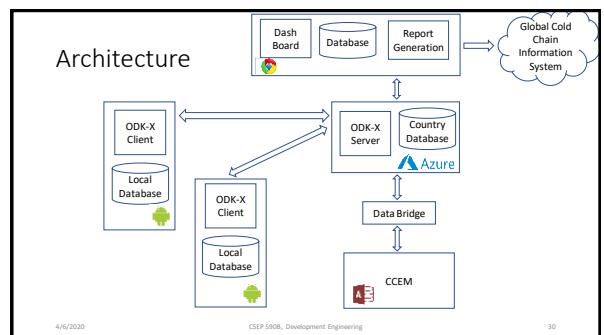
Project Status

- Cold Chain Visualization project
- Cold Chain App prototype
- WHO Deployment
  - Haiti, Pakistan, DRC, Bangladesh
  - Sentinel Surveillance officers
- GAVI Deployment – Uganda
  - Two regions - Kampala and Wakiso (13 Districts)
  - Possible expansion to national scale

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Challenges

- Data Challenges
  - Initial collection and cleaning
  - Name resolution
  - Country administrative regions
- Mobile App
  - Data connection, on-line/off-line
  - Usability
  - Android Phones
- Country Deployment
  - IT support and training
-

- Project Scoping
  - Software can do anything . . .
  - Boundaries with other health information systems
- Hosting and Data Ownership
- Country specific versus general
- Sustainability
  - Planning for partnership with Makerere

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Can this be made global scale?

- Technologically, yes
- Architectural choices are straight forward
- This is not big data
  - Estimate 200,000 Health Facilities and 300,000 Refrigerators
- Data management
  - Administrative and geographic data across 70 countries will be a significant challenge
- App deployment
  - Diverse deployment settings
  - Challenge of producing multiple versions of App on per country basis
- Split global and country management
  - Determination of global verses country data

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Does it provide sufficient value to cover the cost

- Global immunization has substantial resources
- Cost of developing and maintaining this is modest
- But – this only makes sense if has quantifiable benefits

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Value at the Global Level

- Ensure adequate immunization cold chain
- Equipment purchase and distribution
- Implementation and management of equipment
- Market shaping

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Value at the Country Level

- Immunization System Management
- Equipment Allocation
- Equipment Management
- Strategic decisions
- Reporting
- Interactions with Global Level

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Research Questions

- Multiple country deployments underway
  - Thirteen Districts in Uganda
- Potential long term deployment in Uganda
- What can we learn at this stage of the project?

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Technical questions

- Performance and usability of ODK-X application
- Global administrative data pipeline
- Data cleaning pipeline for country data
- Multi country App and system deployment

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Country Questions

- Does the project yield a usable and up to date cold chain equipment inventory
- Updating inventory – last good inventory in Uganda was 2011 with a partial update in 2014
  - Can Uganda's cold chain equipment be inventoried by district cold chain technicians using the mobile application
- Does the system help or hinder district cold chain workers
- In which processes is the data used
- What is the country costs of maintaining and managing the system

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Global Questions

- How do country and global level systems interact
- How does the global cold chain mapper fit with other systems and information sources
- How can more accurate and complete country data be used for improved global support for immunization

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Taking the project live

- Training – January 28-30
  - 4 UW people + 2 PATH
  - 15 cold chain technicians
  - 15 other people from ministry
- Methodology
  - Powerpoint presentation
    - Instruction
    - Walk through
    - Exercises
  - Hands on training with the application

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Training

- 14 of 15 technicians were already familiar with Android phones
- MoH Android phones were distributed to all
- Quick understanding of the cold chain application
- Hard parts of training were
  - Configuring the application
  - Managing synchronization and the possibility of data conflicts

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ODK-X

- Behind the scenes concerns
- App installation a slow process as the entire database is installed
- 30 users simultaneously hitting the server on a unknown networking environment
- Stress test on conflict resolution
- Necessary to collect and reconfigure all devices each night
- Move from a test server to the live server the last day
- Technology worked very well throughout
  - Good performance and few issues

User reactions

- Surprise at list of health facilities for each district
  - Differences between national view and district view
- Discussions on user permissions for operations
  - Handling of dangerous operation
  - Some workflow issues
    - Who has permission to delete, move refrigerators
    - Who handles administrative updates (e.g., adding health facilities)

Training summary

- Capacity development for Development Engineering interventions is critically important
- A practice run with training materials in Seattle was very helpful
- Carefully constructed time schedules had to be discarded
- Last minute changes in the application added to the stress of implementing training
- Lots of work for trainers outside of training sessions
- Considered to have been successful

Deployment: Feb 1 to April 30

- Scale: Approx 400 health facilities and 600 refrigerators
- Data update (through March 15): Approx 80%
- Information collected on need for refrigerator maintenance and temperature alarms
  - Leading to various actions on refrigerator repair / replacement
  - Existing system where additional information allows new actions
  - Demonstrates feasibility of collecting performance data
- A small number of erroneous entries
  - Usability / training issue
- One escalated issue on synchronization

Questions and Discussion