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

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.

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

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

Engineering

- Domain Understanding

- General Principles

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”

Mapping the Global Immunization Cold Chain

Richard Anderson

University of Washington

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

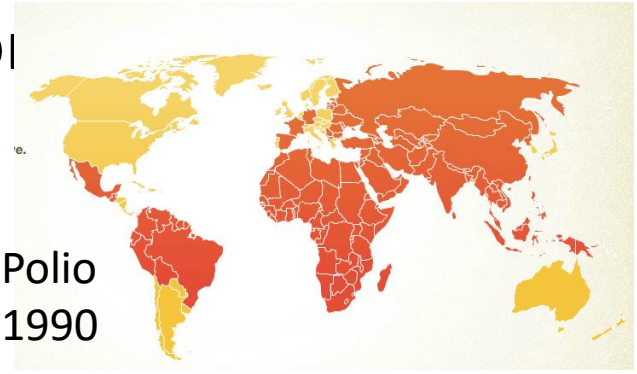
- Mapping the global immunization cold chain
- Construct an accurate cold chain equipment inventory for all low- and medium-income countries

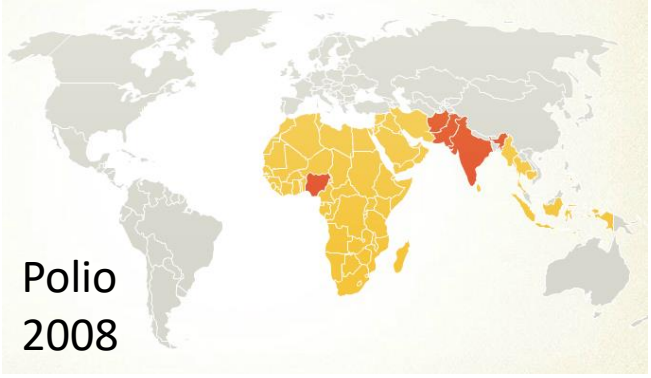
Why is this an interesting Development Engineering problem?

- 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

Why this is important: Immunization

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



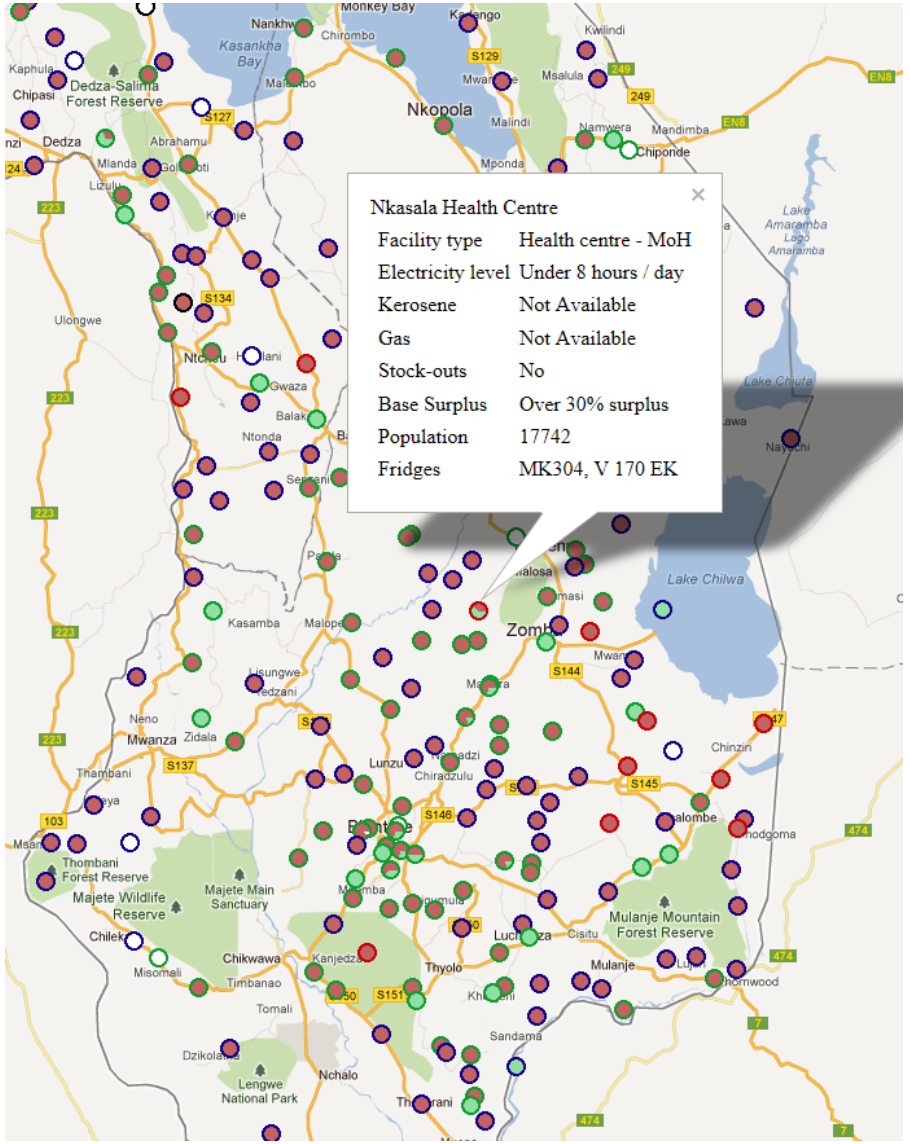


Why this is important: Immunization Logistics

- 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

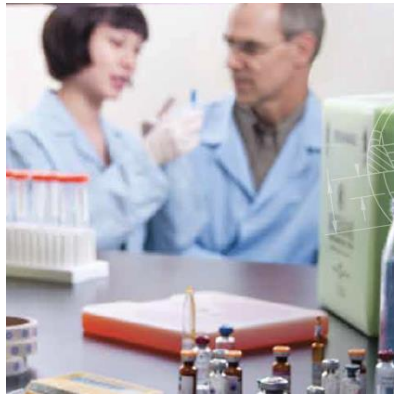
Why this is important

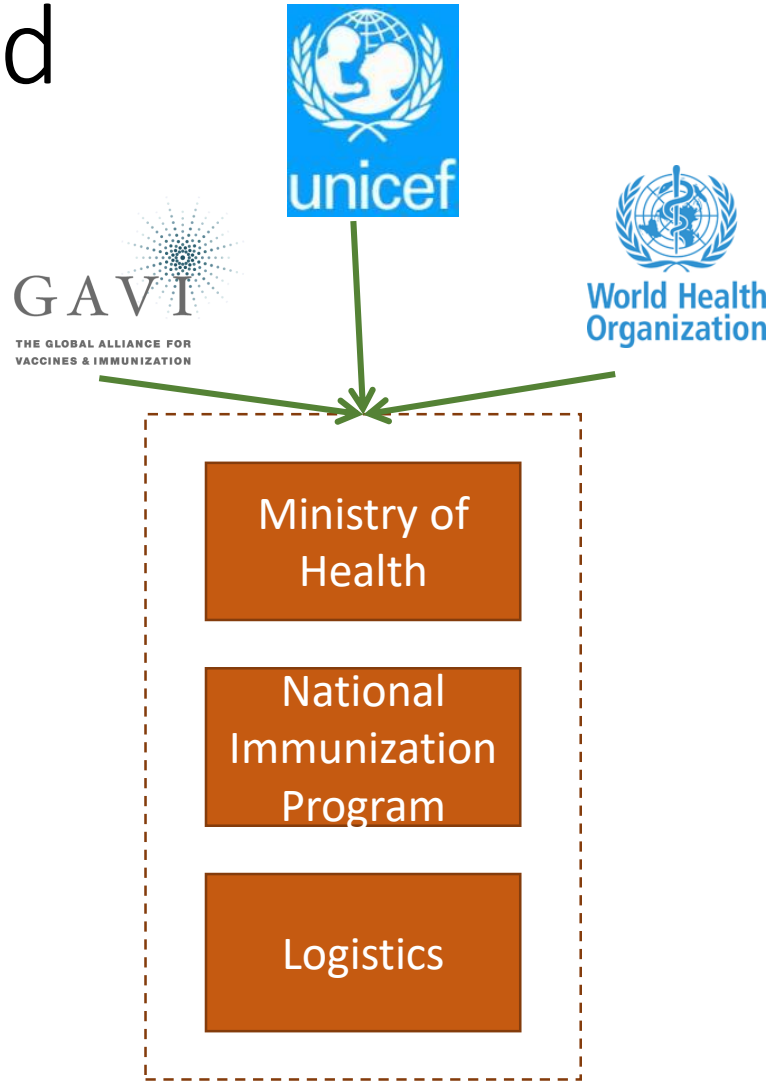
- This information is critical for decision making for managing the global immunization cold chain



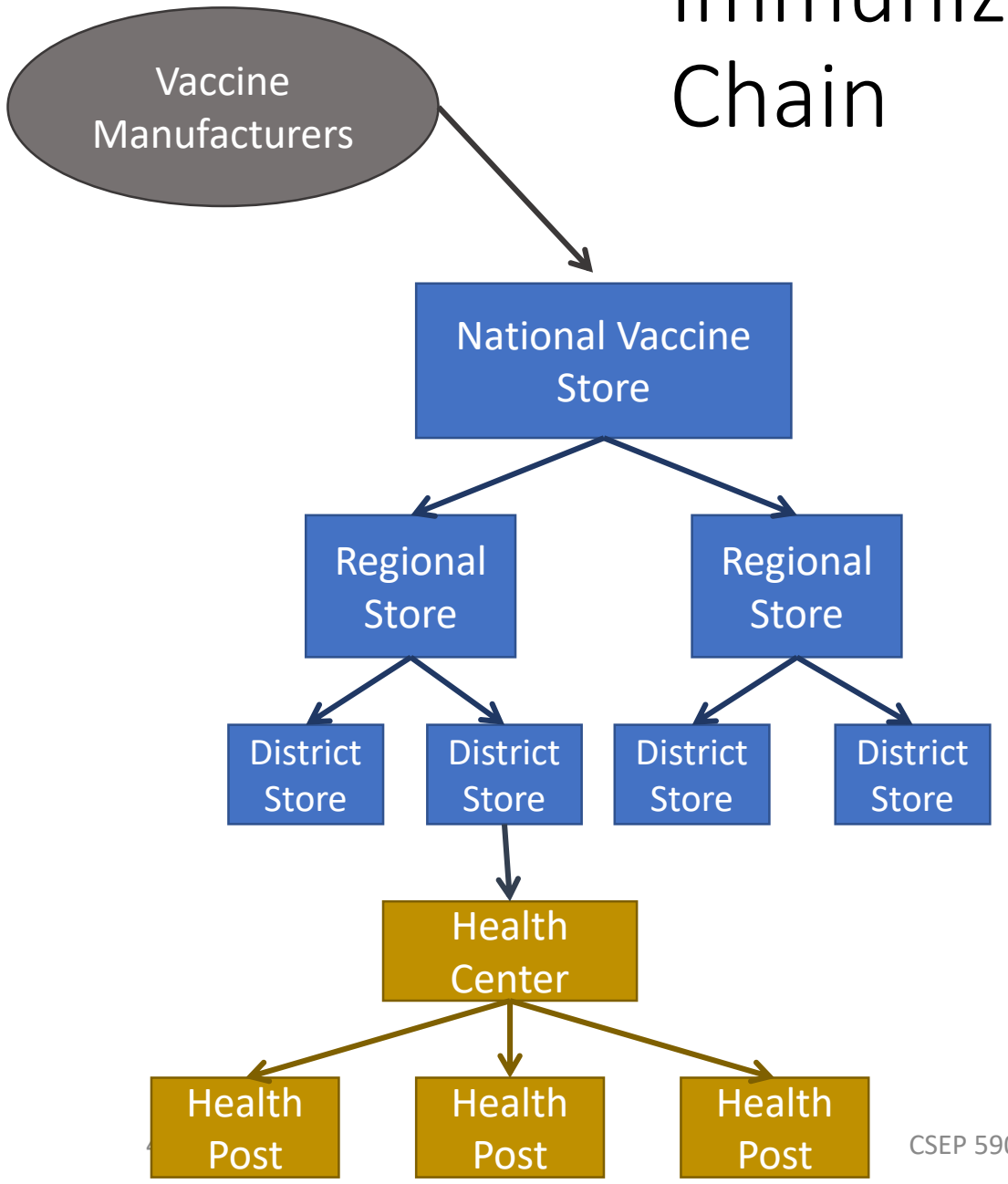
Immunization Domain Background

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





Immunization Cold Chain

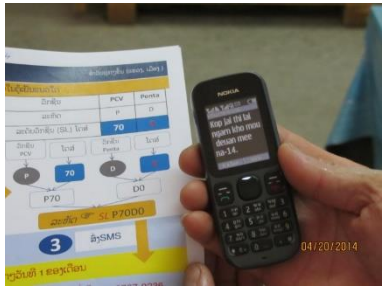


Immunization Cold Chain Challenges

- 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

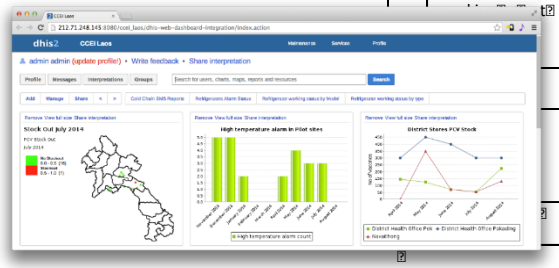
My background in immunization logistics

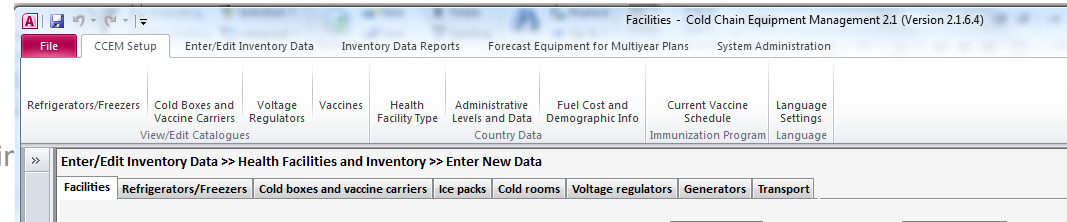
- Sabbatical with PATH (2008-2009)
- CCEM Project
- Country projects: Nicaragua, Kenya, Zimbabwe, Malawi, Nigeria, Ghana, Uganda, India, Pakistan, Laos
- Multiple projects on cold chain information systems
  - DHIS2 for Cold Chain Inventories
  - SMS Temperature Reporting
- Promoted Cold Chain Equipment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



Refrigerator

	Name	Type	Comments	Req.
1.	UniqueID	String	UniqueID for the application. (This ID should be unique across all asset types)	Y
2.	ModelID	String	Key into an official catalog. Information about the model is derived from this.	Y
3.	Equipment tracking ID	String	Ideally, the real Serial number. However, this is not always available or maintained at the facility.	N
4.	BarCode	String	If a barcode is used, the information can be stored here	N
5.	Year	Numeric	Year of acquisition (manufacture). Often not accurate (but may not need to be.)	N
6.	Source	String	Where the equipment came from	N
7.	Working status	Enumeration	Functioning, AwaitingRepair, Unservicable	Y
8.	Reason not	Enumeration	NeedsSpareParts, NoFinance, NoFuel, Surplus, Dead, NotApplicable	N
		Enumeration	InUse, NotInUse, InStoreForAllocation	Y
		Enumeration	For electric equipment, is it connected to a Voltage regulator. Yes, No, Unknown, or NotApplicable. NA for non-electric	N
		Enumeration	Electricity, Gas, Kerosene, Solar, Unknown	N





Problem Statement

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

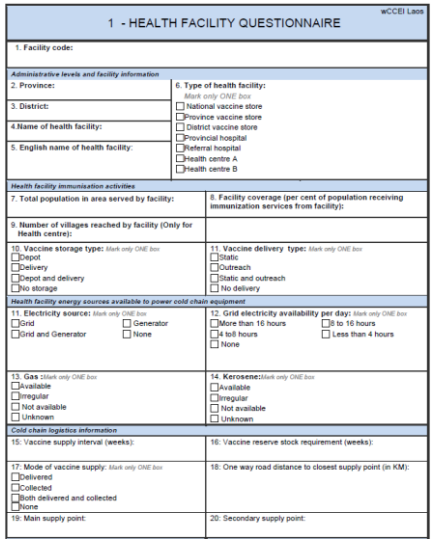
- Caveats
  - Focus on low and middle income countries
  - Multiple levels of dashboards and distinction between global and country data bases

2010 data

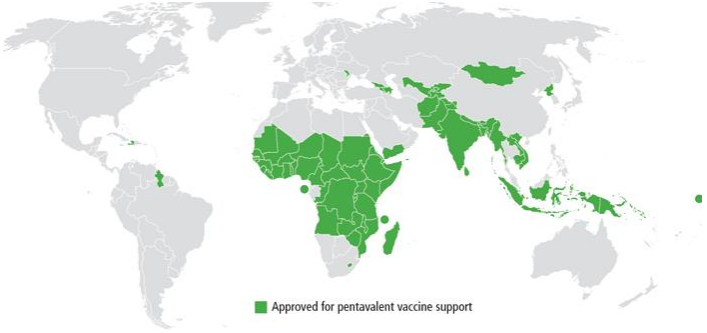
Kenya: 5306 facilities, 4946 refrigerators, Population 41 M
Malawi: 827 facilities, 1426 refrigerators, Population 15 M
Uganda: 2846 facilities, 3153 refrigerators, Population 35 M
Zimbabwe: 1605 facilities, 3080 refrigerators, Population 14 M

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



Vision



THE REPUBLIC OF UGANDA
MINISTRY OF HEALTH

Country Cold Chain Information System

Country Cold Chain Information System

Country Cold Chain Information System

Global Cold Chain Information System

JOHNS HOPKINS UNIVERSITY

unicef

World Health Organization

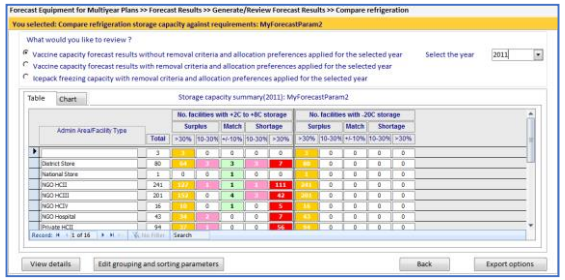
dulas

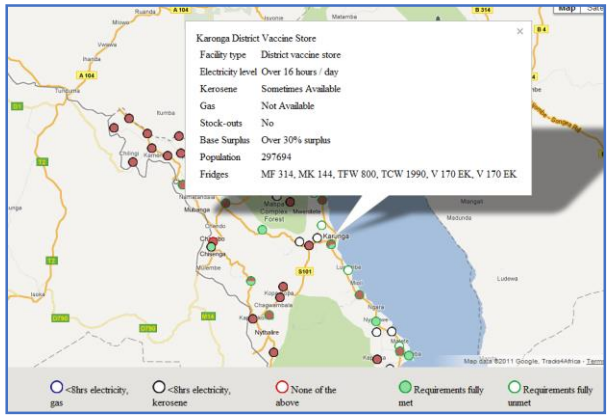
GAVI
THE GLOBAL ALLIANCE FOR VACCINES & IMMUNIZATION

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

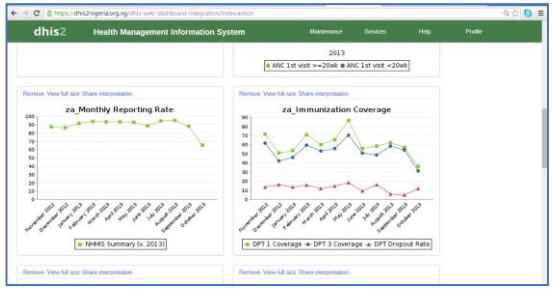


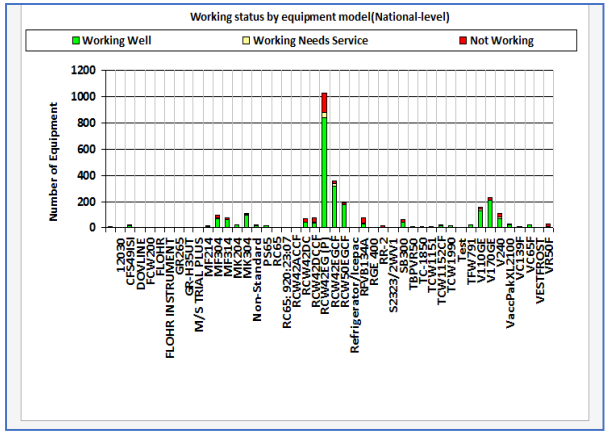


Total population by facility type(National)

Admin Area	Facility Type	No. Facilities	Minimum	Maximum	Mean
National		3	49,807	49,807	49,807
National	District Store	80	2,977	1,189,142	291,336
National	Health Center 2	1202	200	212,173	10,726
National	Health Center 3	989	708	809,837	18,428
National	Health Center 4	184	2,145	303,171	33,854
National	Hospital	126	1,288	2,000,000	52,429
National	National Store	1	28,653,578	28,653,578	28,653,578
National	Sub-district store	32	4,665	479,663	108,236
		TOTAL			38,019

Areas included:
Whole Country





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

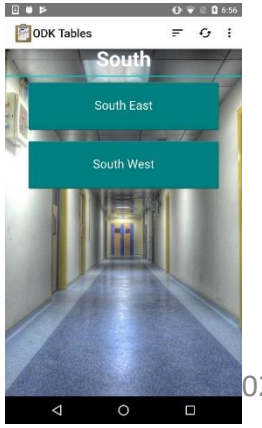
ODK-X

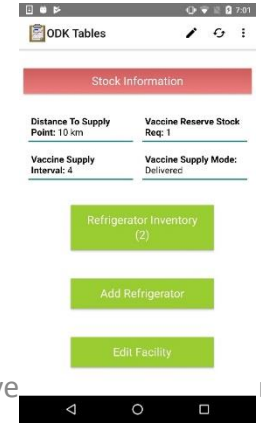
- Mobile data collection on Android Phones. Project started at University of Washington by Professor Gaetano Borriello
- Open Data Kit 1.0 aka ODK
  - Submission of forms
- Open Data Kit 2.0 aka ODK-X
  - Synchronization with a database
- Open source tools. Strong commitment to contributing to global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

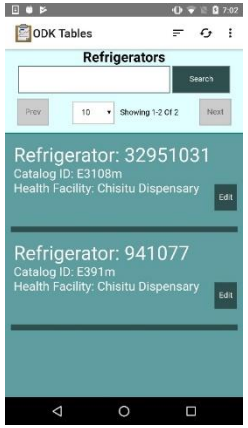
Cold Chain App

- App built on top of the ODK-X platform
  - Combination of ODK Survey and ODK Tables
  - Written in Java Script

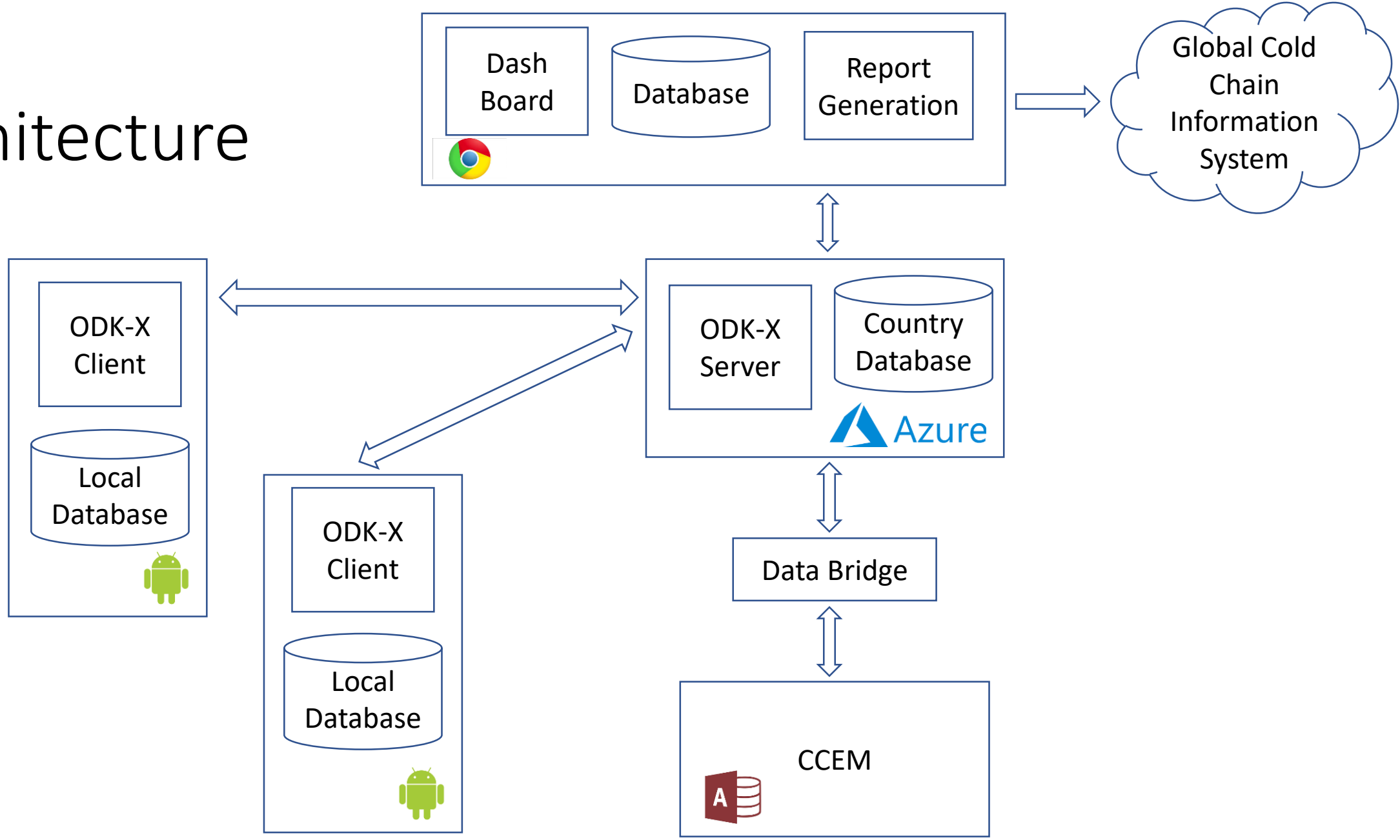
- Manage a database of health facilities and refrigerators associated with facilities







Architecture



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

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

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

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

Value at the Global Level

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

Value at the Country Level

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

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?

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

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

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

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

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

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