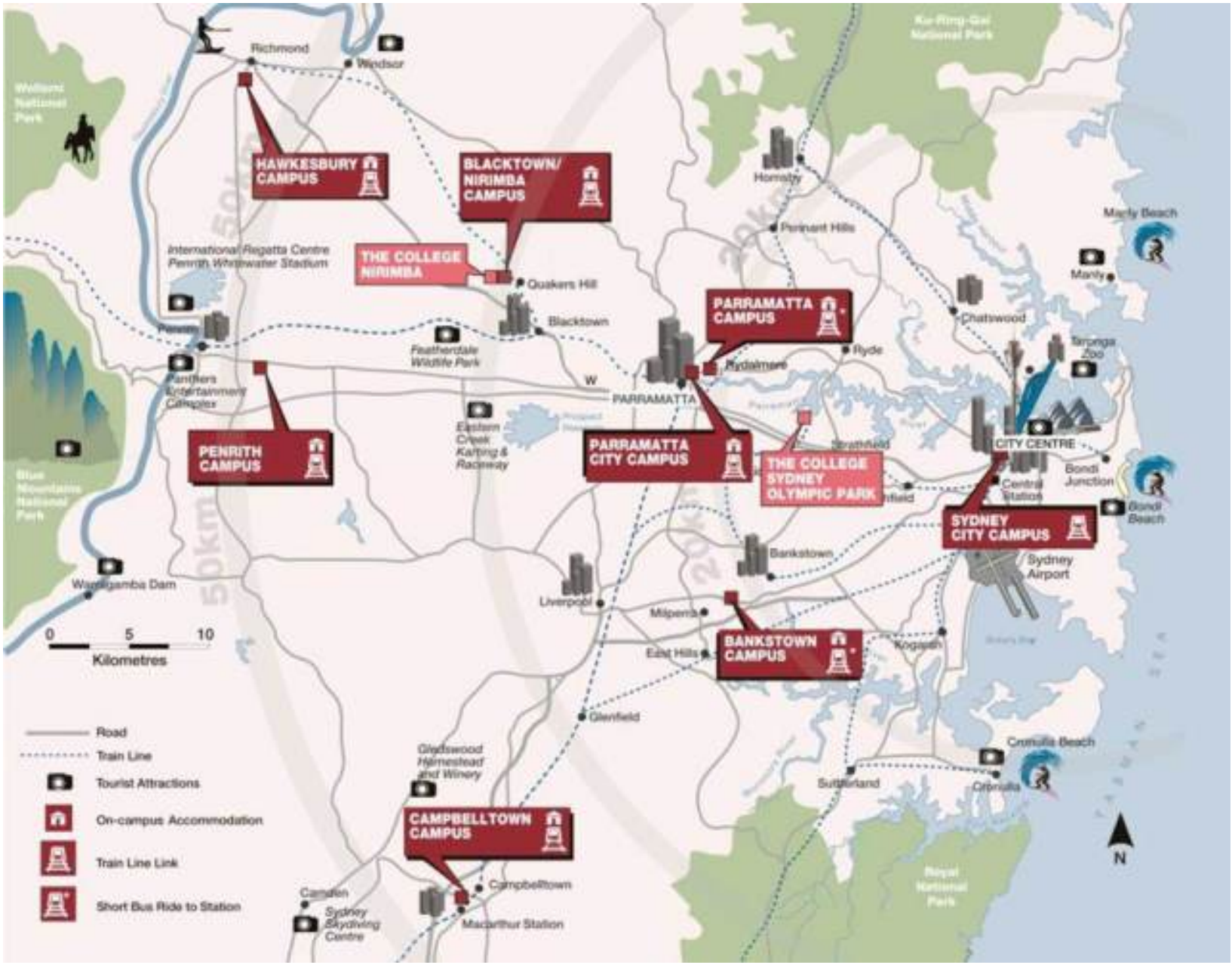
WESTERN SYDNEY UNIVERSITY

From Invention to Innovation: Computing Research that Makes an Impact

Professor Athula Ginige and Dr. Bahman Javadi
School of Computing, Engineering and Mathematics
Western Sydney University
Australia

Where WSU Located



About WSU

- One of the largest universities in Australia
- Largest undergraduate commonwealth funded university
- Over 42,000 students
- Culturally diverse student body
- ‘Bringing knowledge to life’
- Multi-campus structure

Definitions

"Research **engagement** is the interaction between researchers and research end-users outside of academia, for the mutually beneficial **transfer** of knowledge, technologies, methods or resources**"** (ARC 2017).

"**Research impact** is the contribution that research makes to the economy, society, environment and culture **beyond the contributions to academic research**" (ARC 2017).

End user: An individual, community or organisation external to academia that will directly use or directly benefit from the output, outcome or result of the research (***Exclusions***: Publicly funded research organisations [CSIRO, AIMS, ANSTO etc]; other higher education providers; organisations that are affiliates, controlled entities or subsidiaries of a higher education provider [e.g. Medical Research Institutes])

Seminar Outline

- Digital Knowledge Ecosystem for Agribusiness
  - Invention
    - Journey that led to discovery of Digital Knowledge Ecosystem to coordinate agriculture market.
  - Innovation
    - Developing a value proposition and taking the solution to agriculture domain stakeholders.

- Emerging Research Opportunities
  - Mobile-based information systems to mitigate hidden hunger
  - Novel smart nutrition monitoring system
  - Digital Health and User Empowerment

Digital Knowledge Ecosystem for Agribusiness

Over Production problem in Sri Lanka

Troubled farmers erect tomato Pandol for Poson

Source: Ada Derana

Wednesday 15th June 2011

THE SUNDAY TIMES
Sunday November 13, 2011

Leeks have dropped in price to Rs. 6 a kilo, good news for the consumer but disastrous news for the farmer

Leeks cultivators desperate as price drops to record low

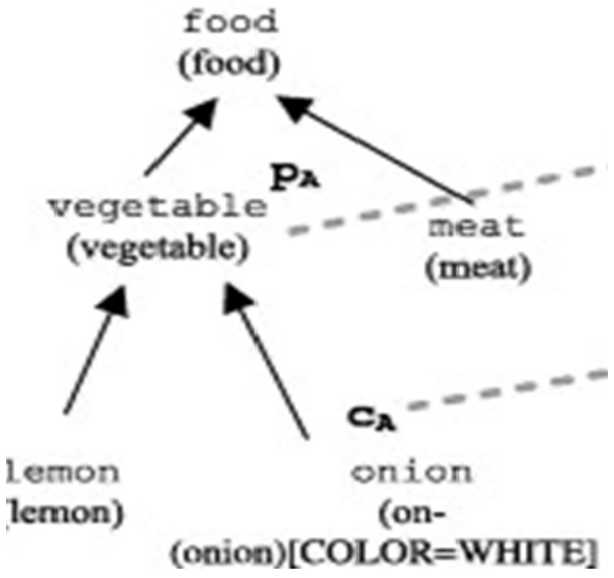
N'Eliya carrot farmers in the dumps:

Bumper harvest, but prices low

Source: The Sunday Times, April 22, 2012

Root Cause - Lack of Context specific Actionable Information

A (ontology O_P)



Sourcing and Generating Information

- **Prior Knowledge - Quasi Static**
  - What Crops will grow in my farm
  - What fertiliser to use
- ➔ Can be sourced from published domain knowledge

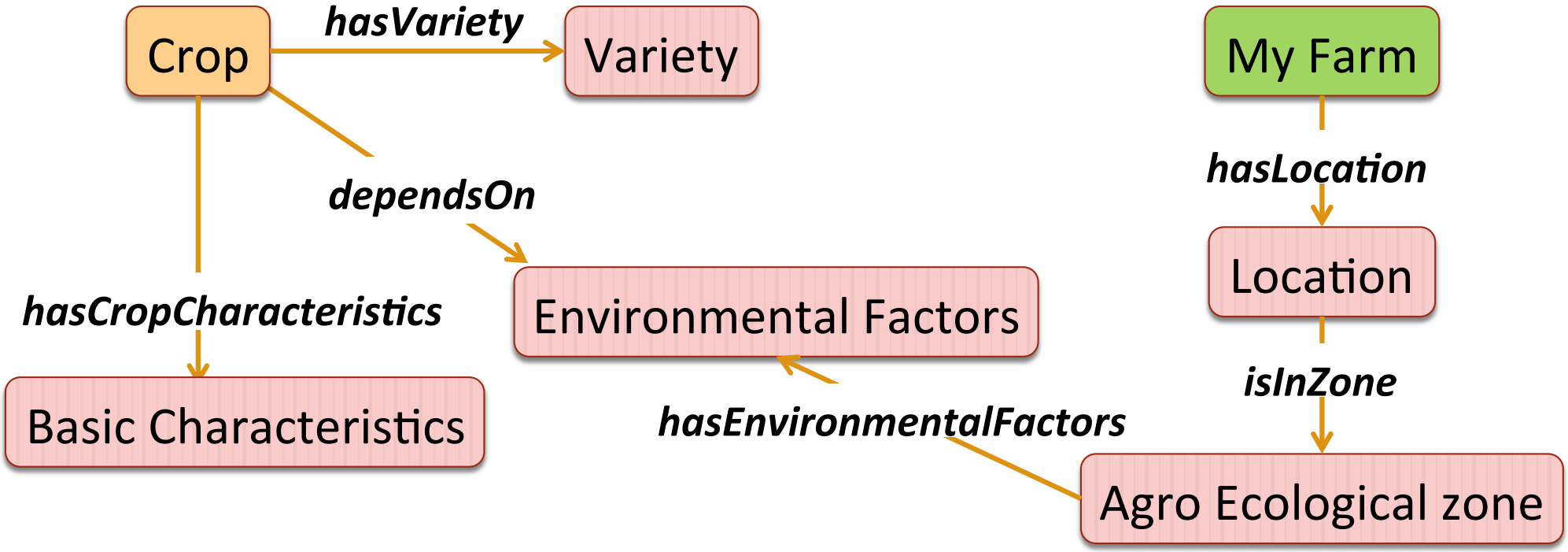
- **Situational Knowledge - Dynamic**
  - What is the current production level of a crop
  - What is the buying price of a vegetable in a market.
- ➔ Need to be generated from Transaction Data; data captured while user is performing a task that is of value to the user.

Farmers' Information Needs in Context

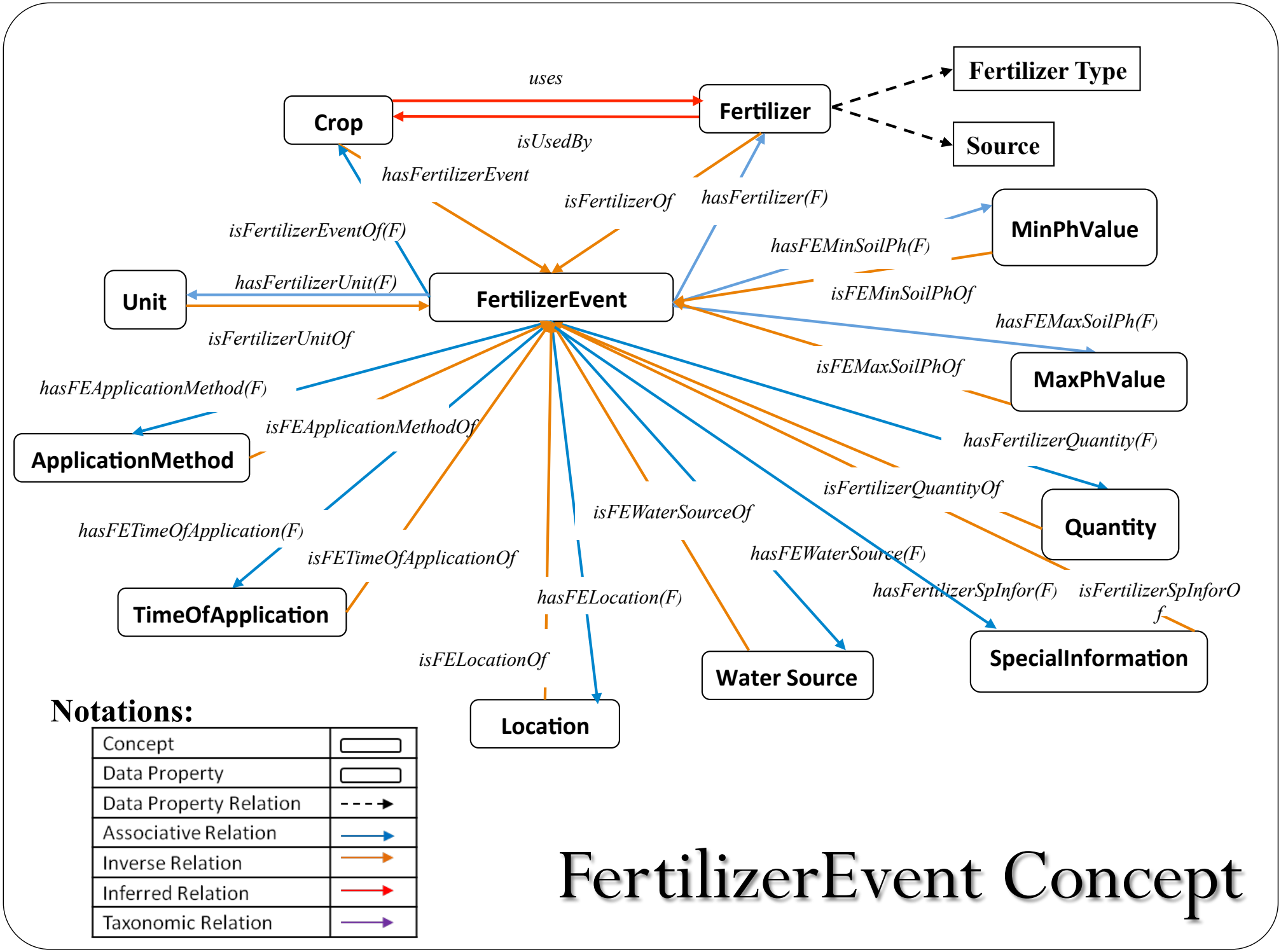
Farmers' Information Needs	Farmers' Information Needs in Context	Generalising Contextualised Information	Query in First Order Logic (FOL)
What are the suitable crops to grow?	***Suitable crops based on the Environment:***		
	• Which crops are suitable to grow in the 'Dambulla' area?	•Which crops are suitable to grow in specified Location?	(∃x)(Crop(x)) ∧ RegionalArea(Dambulla) ∧ grows(x, Dambulla);
	• What are the suitable vegetable crops for 'UpCountry', applicable to the 'Well-drained Loamy' soil, and average rainfall > 2000 mm?	•What are the suitable *Types of Crops* for specified *Location*, applicable to the specified *Soil types/ characteristics*, and other *Conditions* ?	(∃x)(Vegetable(x))∧ SoilType(Loamy)∧ SoilDrainage(Well_drained)∧ hasSoilFactor(x,Loamy)∧ hasSoilFactor(x,Well_drained)∧ (∃y Integer(y) ∧ hasMinRainfall(x,y)∧ (2000 ≤ y));
	Suitable crops based on Preferences of Farmers:		
	• What Brinjal's varieties can resist the 'Bacterial Wilt' disease?	•What *Crop's varieties* can resist the specified *Disease*?	…
	…	…	…

Providing Information in Context

What *Crops* will grow in *My Farm*?



Walisadeera, A. I., Wikramanayake, G. N., Ginige, A.: An Ontological Approach to Meet Information Needs of Farmers in Sri Lanka. In ICCSA 2013 Part I, Lecture Notes in Computer Science, 7971, pp. 228–240. Springer-Verlag, Berlin Heidelberg (2013)


Crop
Fertilizer
Fertilizer Type
Source
uses
isUsedBy
hasFertilizerEvent
isFertilizerOf
hasFertilizer(F)
isFertilizerEventOf(F)
Unit
hasFertilizerUnit(F)
isFertilizerUnitOf
FertilizerEvent
MinPhValue
hasFEMinSoilPh(F)
isFEMinSoilPhOf
hasFEMaxSoilPh(F)
isFEMaxSoilPhOf
MaxPhValue
hasFEApplicationMethod(F)
isFEApplicationMethodOf
ApplicationMethod
hasFertilizerQuantity(F)
isFertilizerQuantityOf
Quantity
hasFETimeOfApplication(F)
isFETimeOfApplicationOf
TimeOfApplication
isFEWaterSourceOf
hasFEWaterSource(F)
hasFELocation(F)
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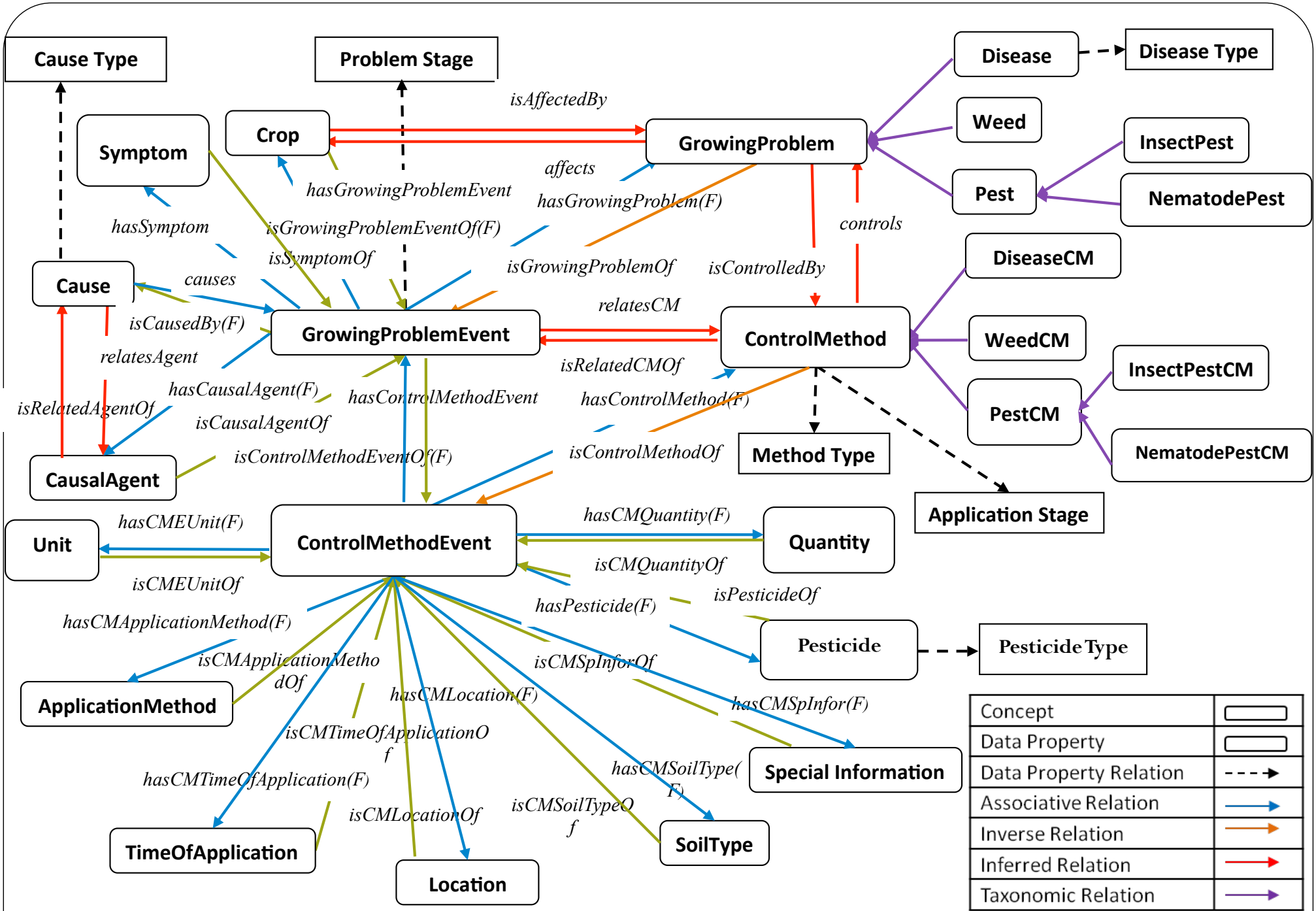
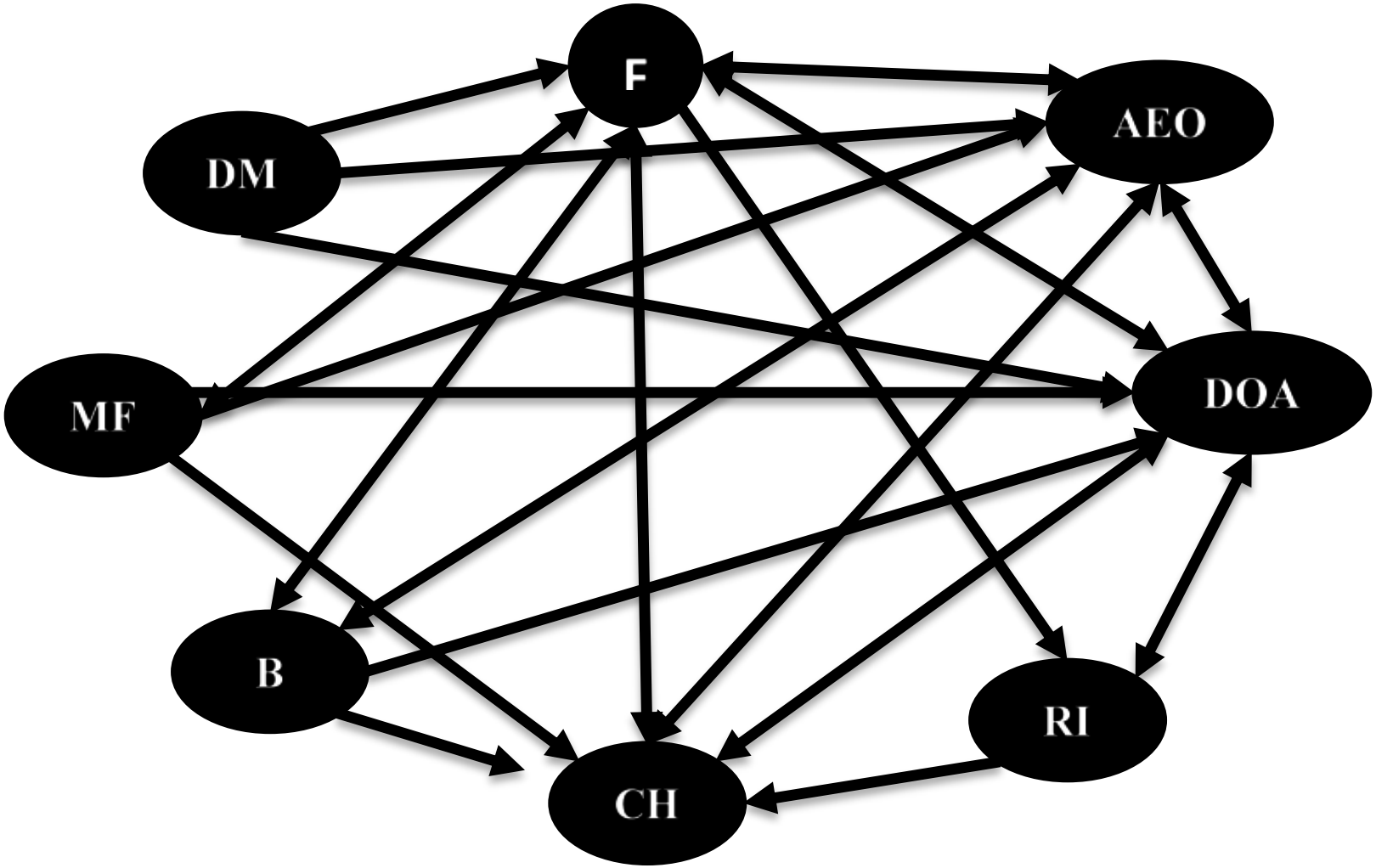
Location
Water Source
hasFertilizerSpInfor(F)
isFertilizerSpInforOf
SpecialInformation
Notations:
Concept
Data Property
Data Property Relation
Associative Relation
Inverse Relation
Inferred Relation
Taxonomic Relation
FertilizerEvent Concept

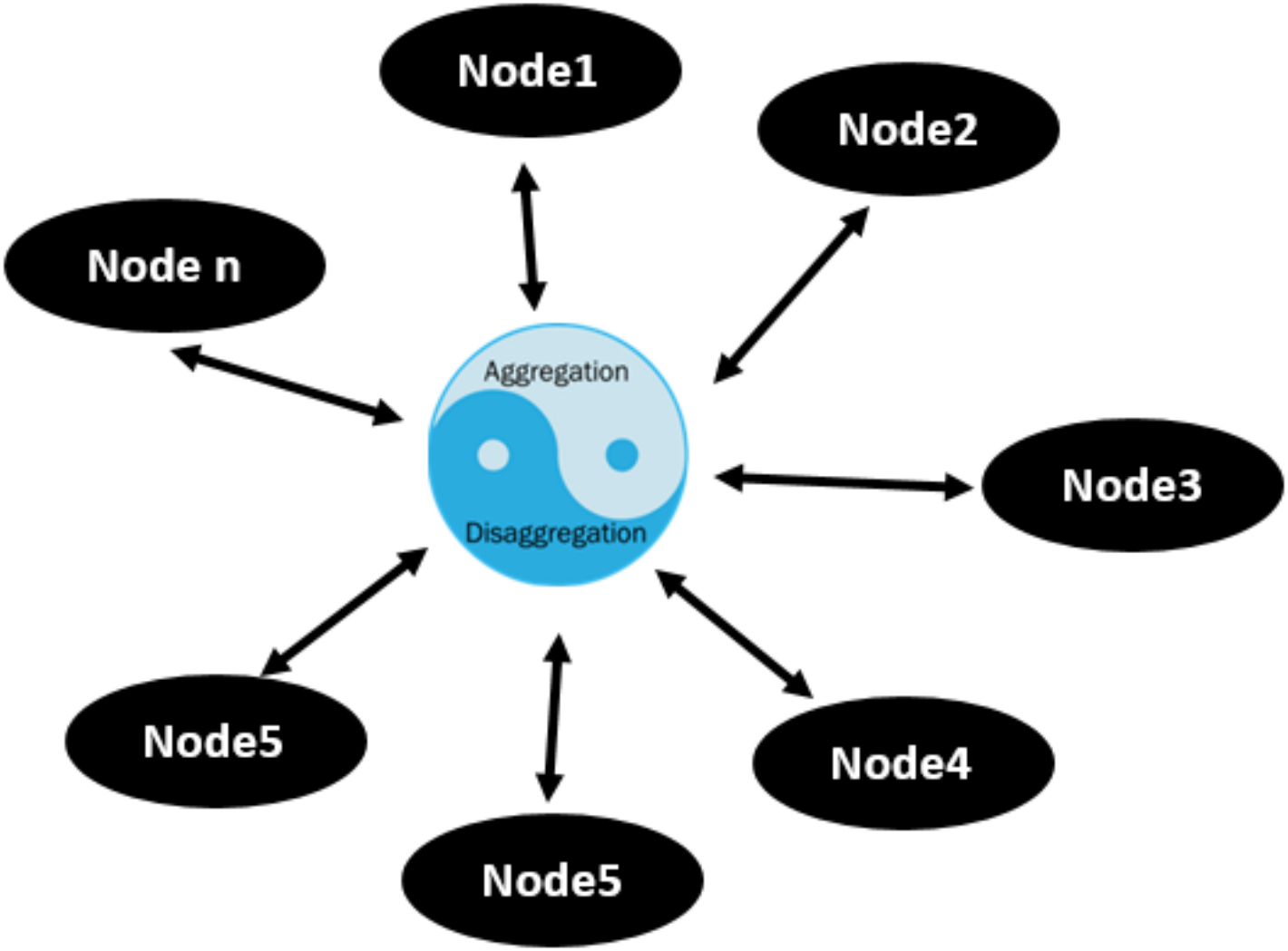


GrowingProblemEvent and ControlMethodEvent

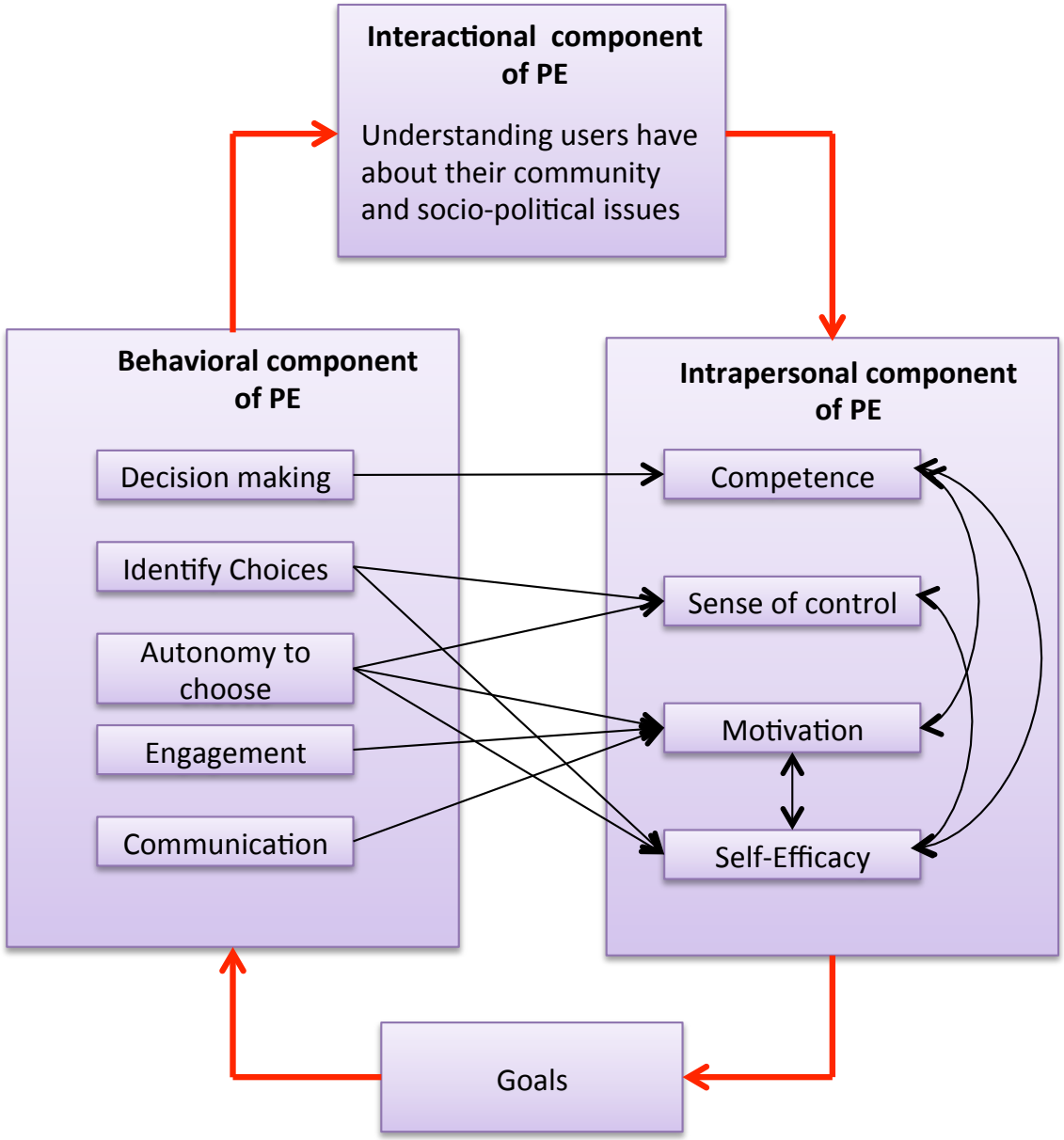
Information Flow Pattern: Stakeholder Centric Information Flow Model



Generalised Architecture for a Holistic Information Flow Model for any Domain

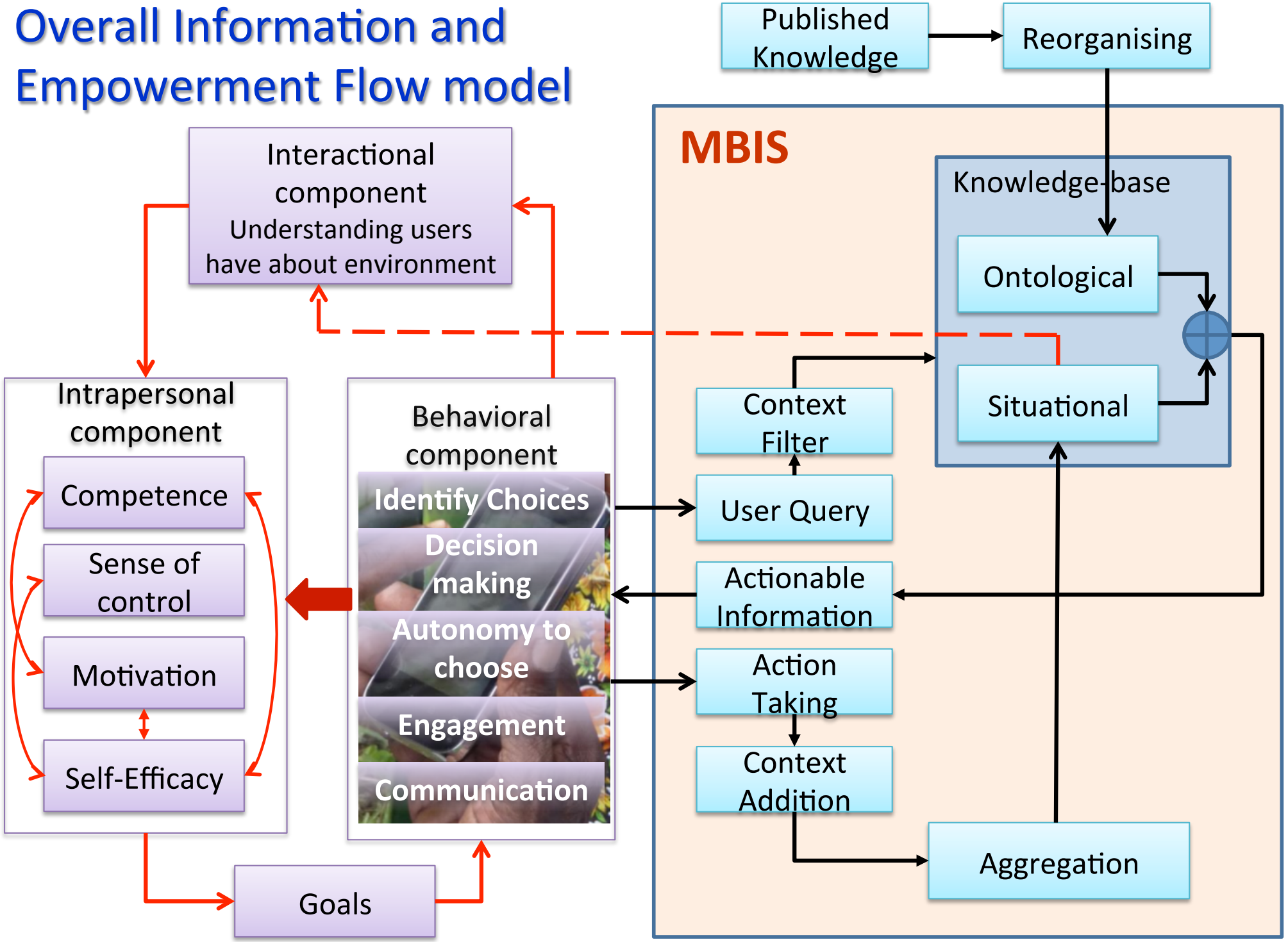


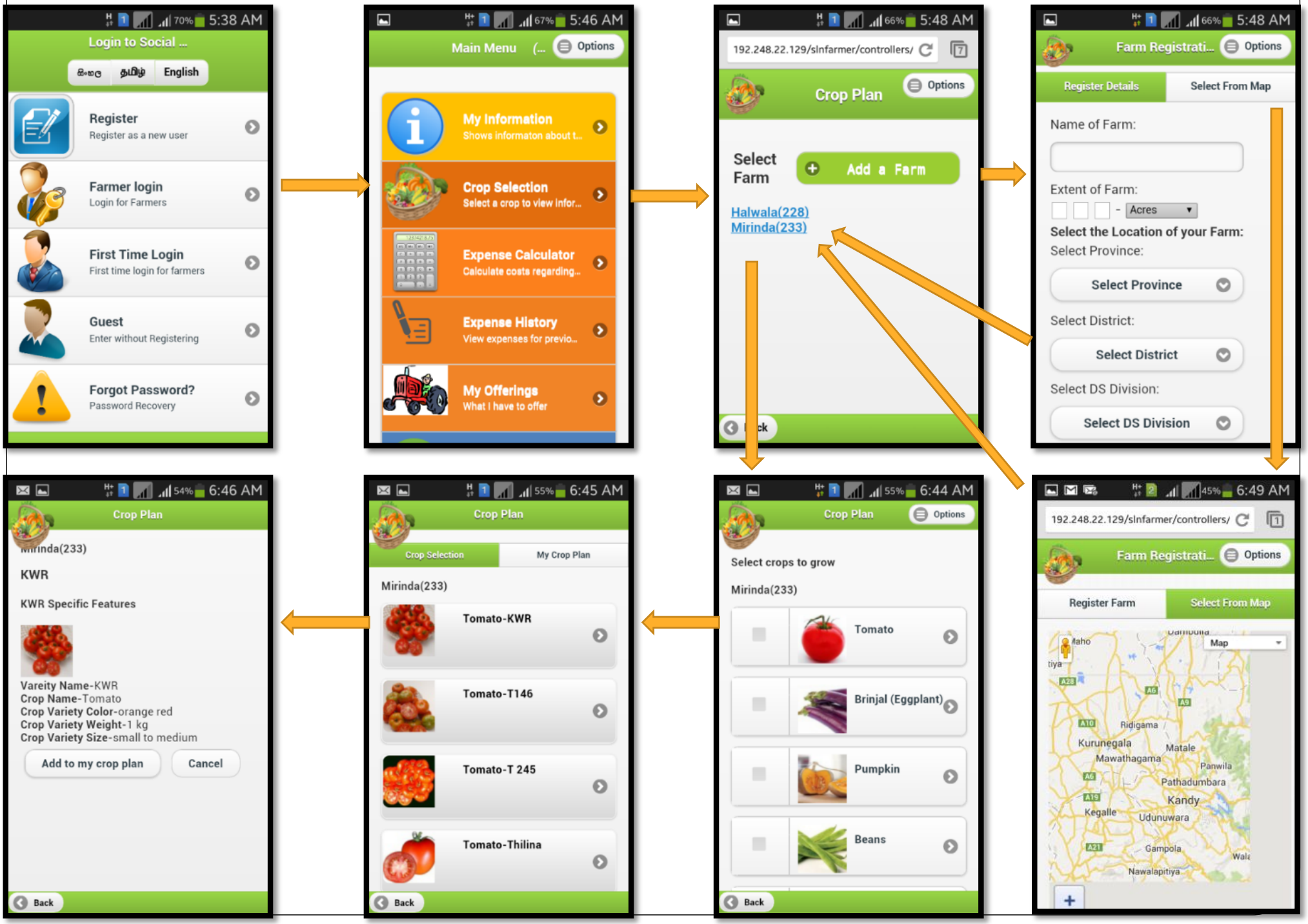
Psychological Empowerment Flow Model

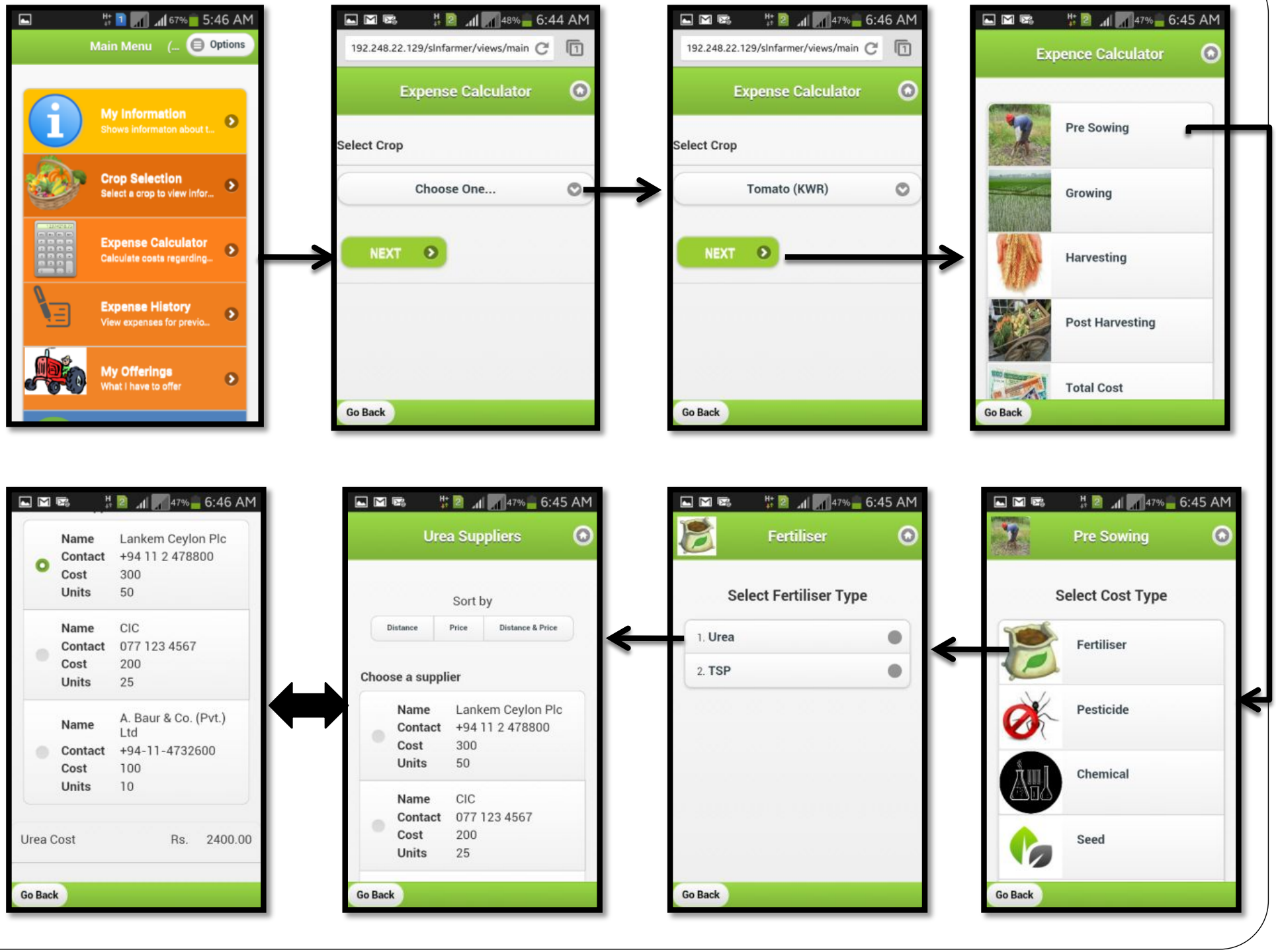


Ref: Ginige, T. and Richards, D. 2015 "Measuring Empowerment to evaluate the impact of a Mobile Based Information System for Sri Lankan Farmers", AMCIS 2015, Twenty-first Americas Conference on Information Systems, Puerto Rico.

Overall Information and Empowerment Flow model




Login to Social ...
සිංහල
தமிழ்
English
Register
Register as a new user
Farmer login
Login for Farmers
First Time Login
First time login for farmers
Guest
Enter without Registering
Forgot Password?
Password Recovery
Main Menu
Options
My Information
Shows informaton about t...
Crop Selection
Select a crop to view infor...
Expense Calculator
Calculate costs regarding...
Expense History
View expenses for previo...
My Offerings
What i have to offer
192.248.22.129/slnfarmer/controllers/
Crop Plan
Select Farm
Add a Farm
Halwala(228)
Mirinda(233)
Farm Registrati...
Register Details
Select From Map
Name of Farm:
Extent of Farm:
Acres
Select the Location of your Farm:
Select Province:
Select Province
Select District:
Select District
Select DS Division:
Select DS Division
Crop Plan
Mirinda(233)
KWR
KWR Specific Features
Vareity Name-KWR
Crop Name-Tomato
Crop Variety Color-orange red
Crop Variety Weight-1 kg
Crop Variety Size-small to medium
Add to my crop plan
Cancel
Back
Crop Selection
My Crop Plan
Mirinda(233)
Tomato-KWR
Tomato-T146
Tomato-T 245
Tomato-Thilina
Select crops to grow
Tomato
Brinjal (Eggplant)
Pumpkin
Beans
Register Farm
Select From Map
Map
Ridigama
Kurunegala
Matale
Mawathagama
Panwila
Pathadumbara
Kandy
Kegalle
Udunuwara
Gampola
Nawalapitiya


Main Menu
Options
My Information
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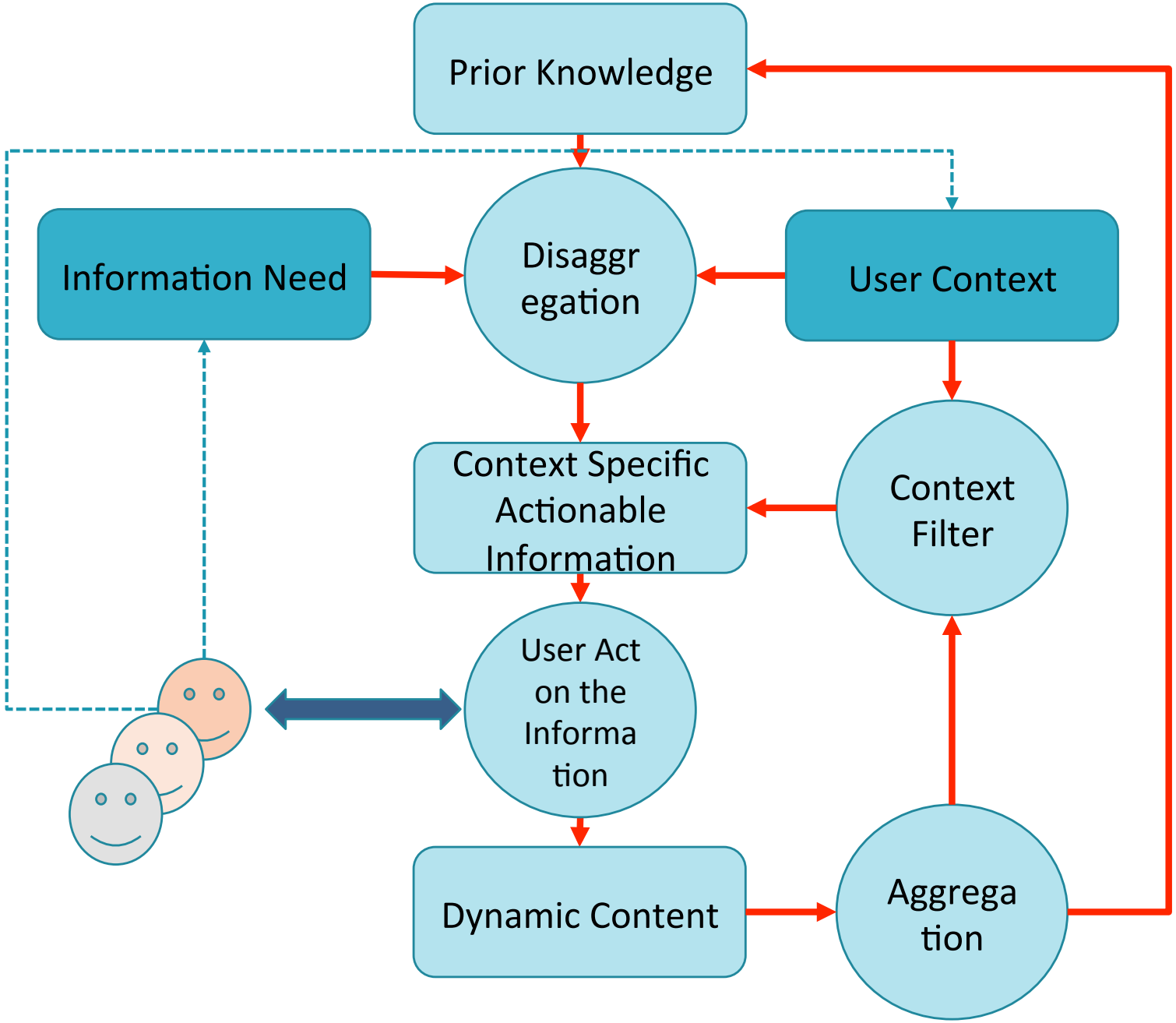
Crop Selection
Select a crop to view infor...
Expense Calculator
Calculate costs regarding...
Expense History
View expenses for previo...
My Offerings
What I have to offer
192.248.22.129/slnfarmer/views/main
Expense Calculator
Select Crop
Choose One...
NEXT
Go Back
Tomato (KWR)
Expence Calculator
Pre Sowing
Growing
Harvesting
Post Harvesting
Total Cost
Pre Sowing
Select Cost Type
Fertiliser
Pesticide
Chemical
Seed
Fertiliser
Select Fertiliser Type
1. Urea
2. TSP
Urea Suppliers
Sort by
Distance
Price
Distance & Price
Choose a supplier
Name Lankem Ceylon Plc
Contact +94 11 2 478800
Cost 300
Units 50
Name CIC
Contact 077 123 4567
Cost 200
Units 25
Name A. Baur & Co. (Pvt.) Ltd
Contact +94-11-4732600
Cost 100
Units 10
Urea Cost Rs. 2400.00

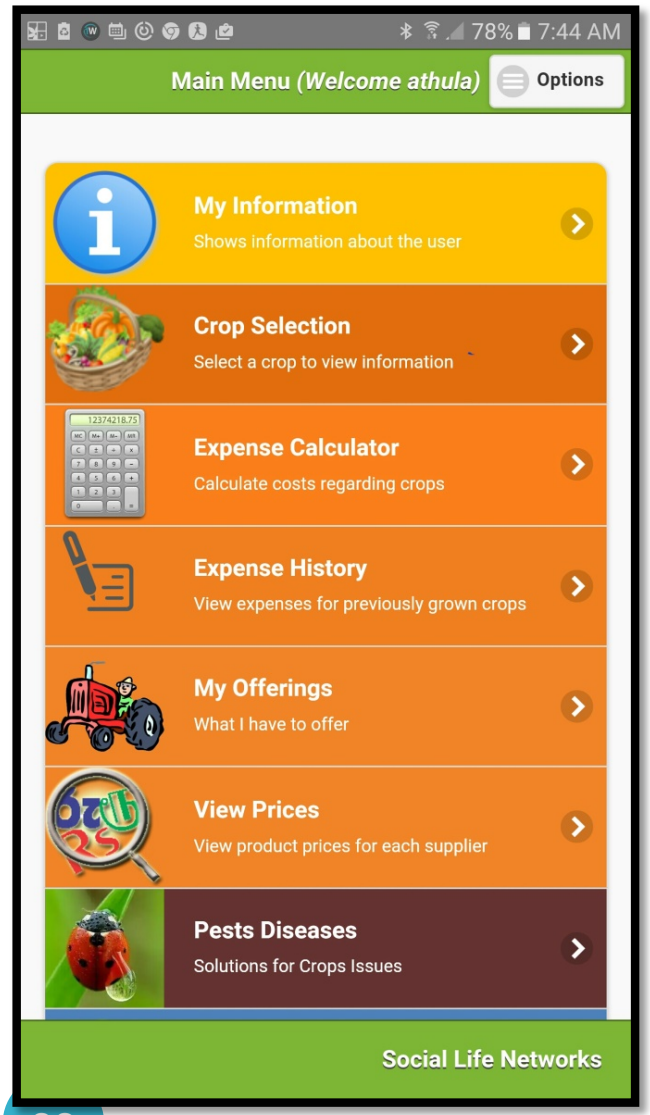
Digital Ecosystem Evolution

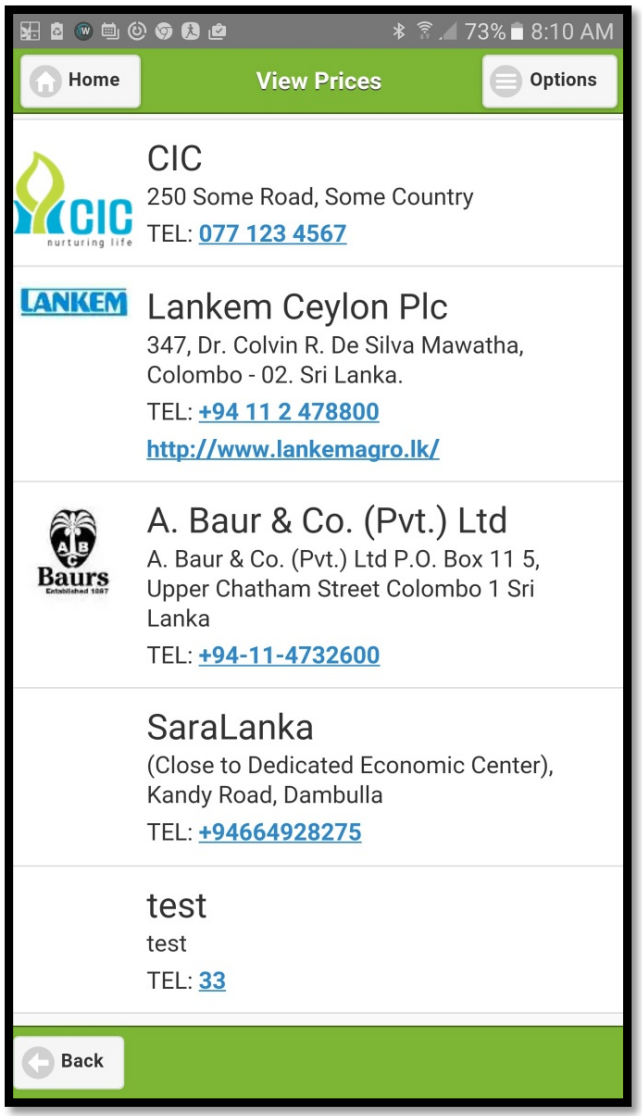


Evolution of the Ecosystem - Observations

April 2015	• System was deployed among the pilot group
June 2015	• All Major Agro chemical companies started to provide prices of chemicals
Sept 2015	• Sri Lanka Government requested a proposal to manage agriculture production
Nov 2015	• Government announced the phase 2 of the Project in the 2016 National Budget
Jan 2016	• Major Buyers signed up to invest in developing Phase 2
Oct 2016	• Indian Venture Capital company investing in a start-up to deploy the system in Sri Lanka and India
Sept 2017	• Proof of Concept Trial involving 5000 farmers in Telangana State in India

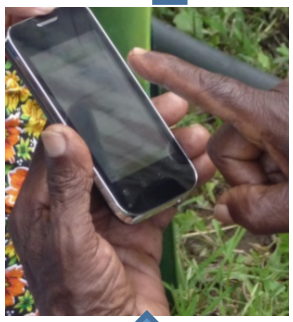
Price Information from Major Agro Chemical Companies in Sri Lanka





Proposal to SL Government - Closing the Loop

Govi Nena



Farmer Decision Making

Food Production

Aggregated Production Captured in Real Time

Mobile based Information System

Continuous Monitoring Dash Board for Agencies

Market Information

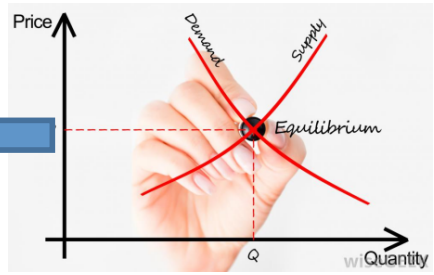
Information on Inputs and Suppliers

Government Incentives

Crop Knowledge

Weather Information

Micro Financing



Policy Setting

ENABLING ENVIRONMENT

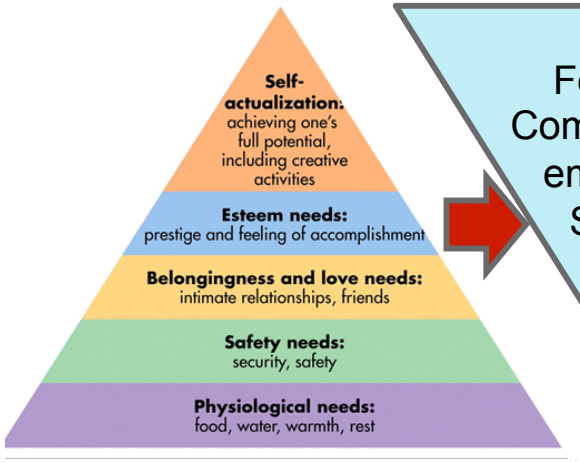
2016 Sri Lanka Government National Budget Speech

Some of these innovations include **GoviNena, a mobile application to support efficient agricultural commodity production,** Energy storage systems etc. Such innovations have a direct impact on the industry concerned as well as contributing to the sustainability of target sectors. **High end equipment acquisition supported with accelerated depreciation** etc. will be made available to **any Company that will partner these innovations to be monetized.** The government will also facilitate these ventures by **providing land or any other resource based on the type of project**.

Innovation Success - Insight

- All top down approaches gave limited success until we discovered another relationship to human needs and behaviours by systematically analysing some popular Social Computing applications.

Fulfilling Human Needs



Formation of Communities and emergence of Secondary Human Needs

Coordination and Exchange of

- Products
- Services
- Information

Cooperation and Markets

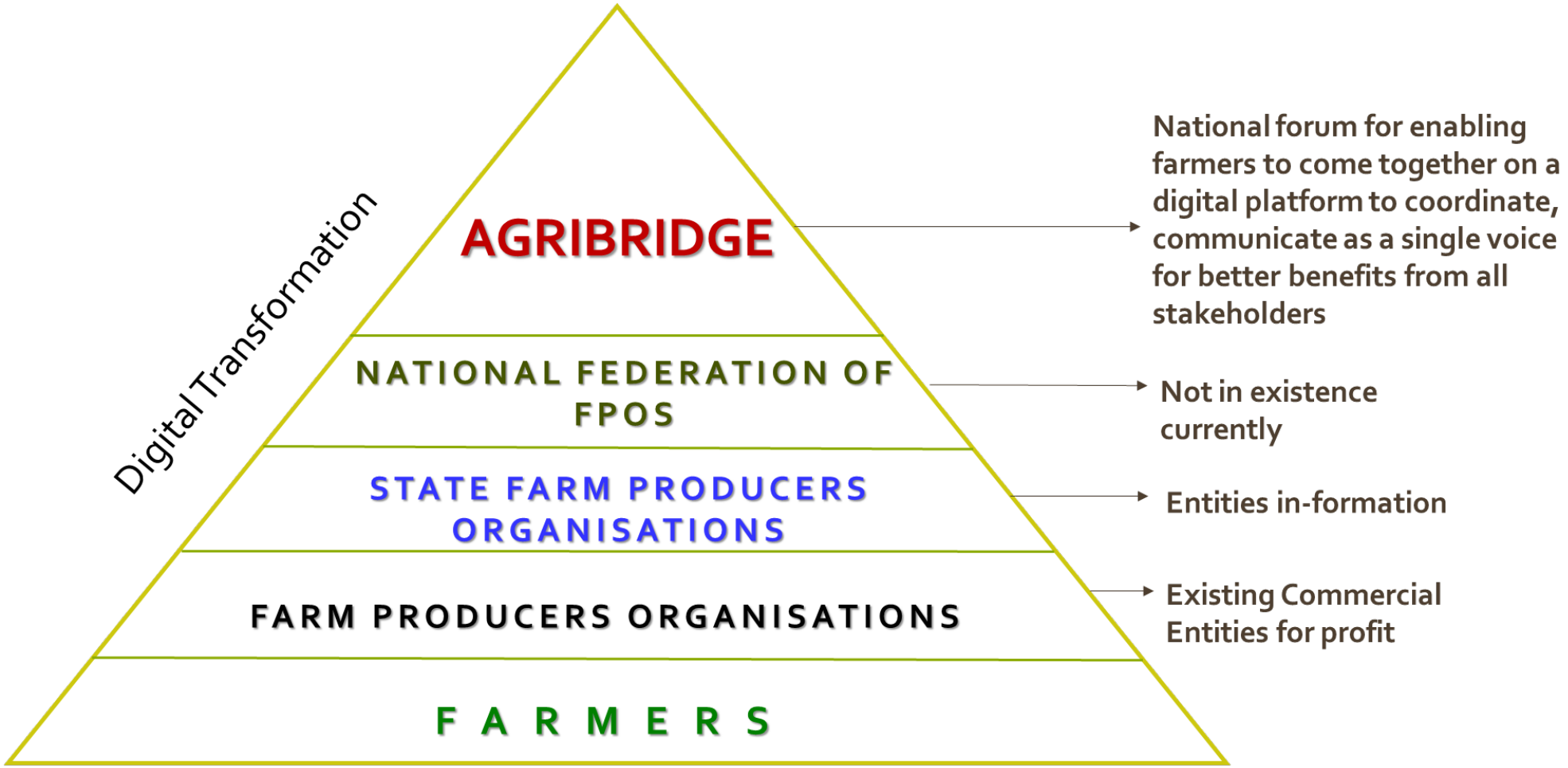
- Exchange Mechanisms
- Currency
- Trust

Trust Bubble

High Transaction cost

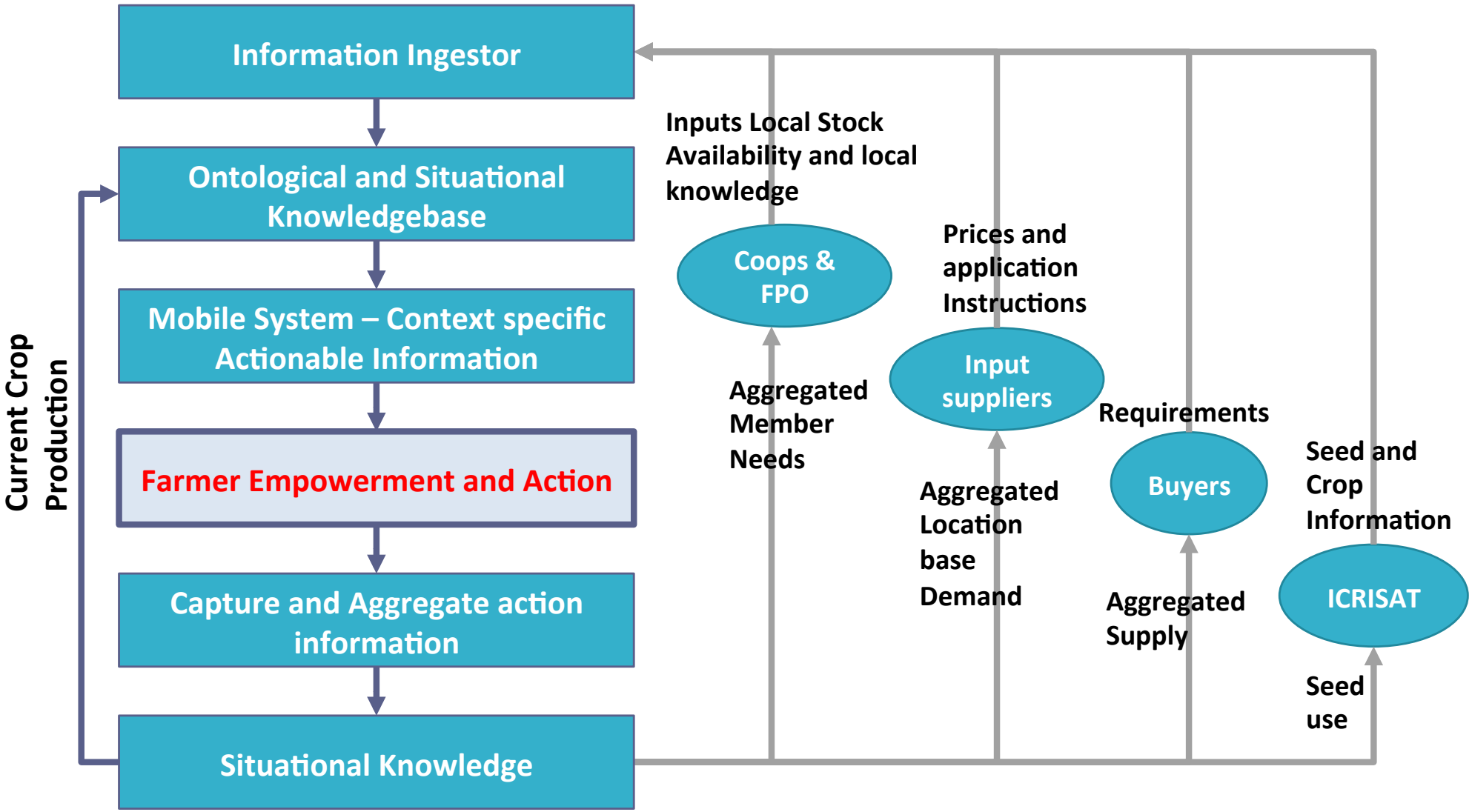
Ref: Fernando, M. D., Ginige, A., and Hol, A. 2016. "Enhancing Business Outcomes through Social Computing," *IADIS International Journal on WWW/Internet* (14:2), pp. 91-108.

Diffusion Model for Gyan Kisan:
Digitally Connected Farming Communities



Base of the pyramid represents the total number of farmers of over 118 Million in numbers. Currently these farmers are geographically scattered and not connected to any kind of digital platform.

Creating Value for Stakeholders



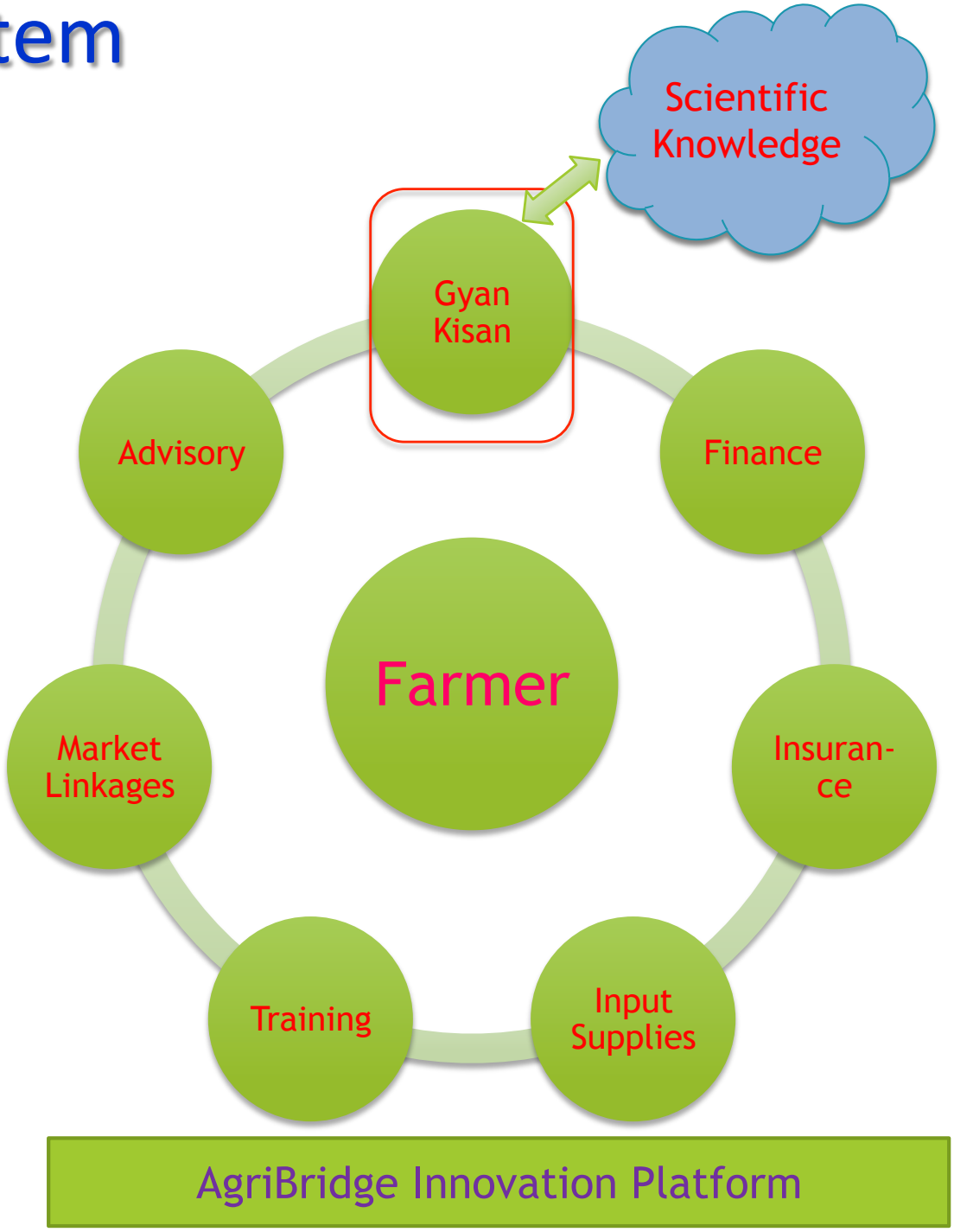
Communities, Coordination and Cooperation

Gyan Kisan Mobile Interface

AgriBridge Ecosystem

Gyan Kisan

- Empowering and uplifting farmer livelihood through knowledge and Market coordination.
- Published scientific knowledge is delivered to farmers as context specific actionable information via a mobile system.
- Enables all Agri stakeholders to effectively optimise and coordinate their offerings based on both published knowledge and real-time information generated by aggregating farmer actions and transactions.



Emerging Research Opportunities

- Mobile-based information systems to mitigate hidden hunger
- Novel smart nutrition monitoring system
- Digital Health and User Empowerment

Nutrition-based Health Issues

- Overweight and obesity in Adults
  - US: 70%
    - $200B
  - Australia: 63%
    - $14B
  - South Africa: 65%
    - 70% for women

Hidden Hunger

26% of preschool children in Kenya are stunted, 37% in Nigeria and 33% in South Africa

http://www.huffingtonpost.ca/howard-schiffer/end-hidden-hunger_b_8215624.html

Project Team

16 Researchers from 4 countries from Australia and Africa

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UNIVERSITY OF NAIROBI

AAUN AUSTRALIA AFRICA UNIVERSITIES NETWORK

Findings from University of Pretoria study

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RM Research Matters

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Research Programmes

The solutions to change the world can be found in the research we do today. This page contains some of the research projects showcased by the University of Pretoria. Click on the buttons below to find out more about how UP researchers are Making today matter.

Food Security in Rural South Africa - Homegrown solutions for South Africa's hungry

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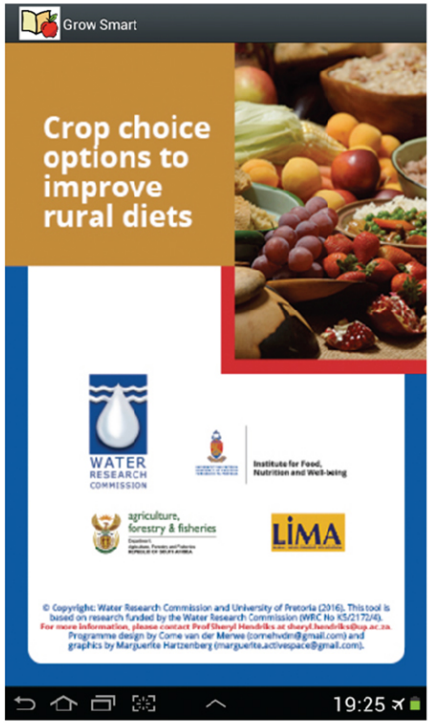
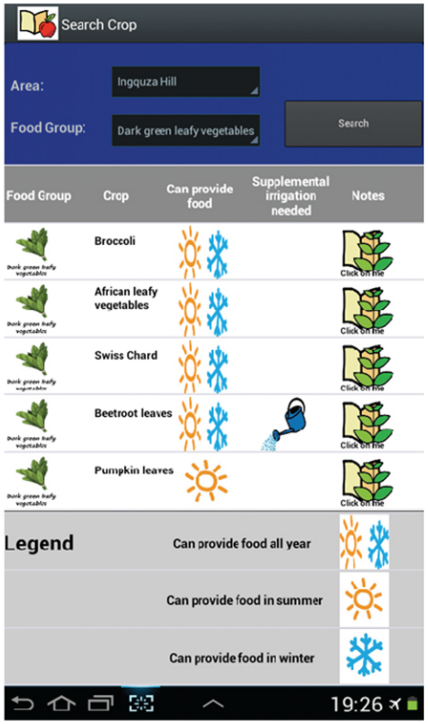
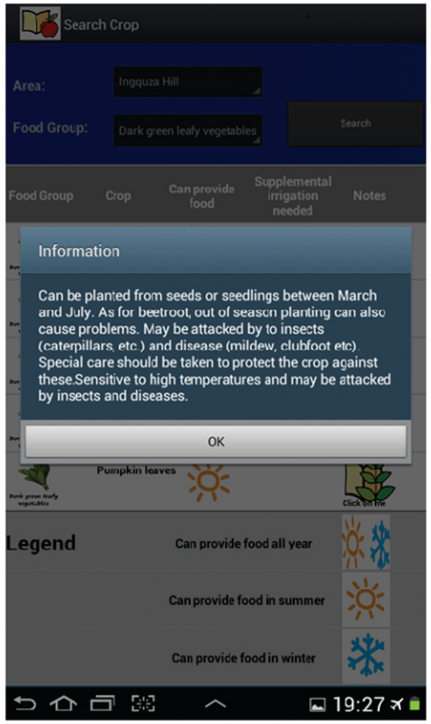






Mobile based Information System for Africa

Geo coordinates

List of Crops that grow in the location

16 Questions to identify the food habits

Identifying missing micro nutrients in the diet

Identifying what food from the list of crops that grow in the location can address the identified micro nutrient deficiency

Recommended fruits and vegetables to be consumed

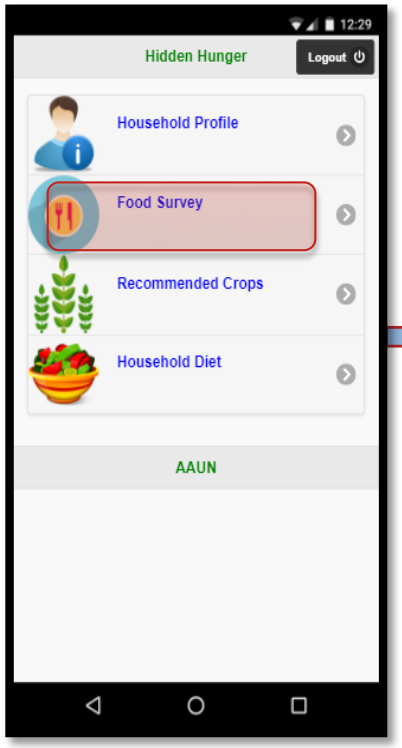
Information on nutritional value

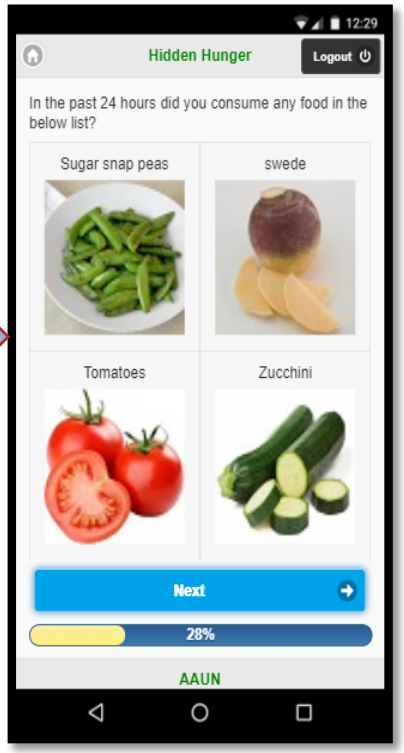
Information on how to grow these crops

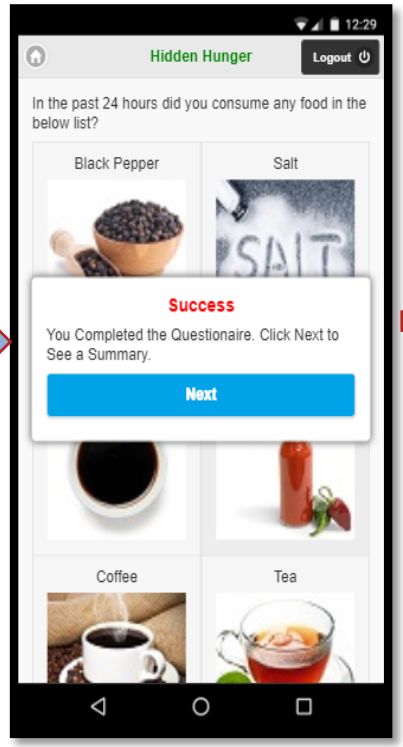
Application Assumptions

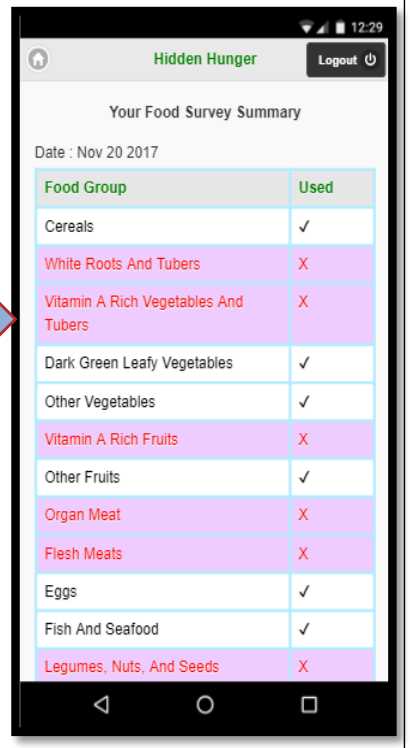
Item	Detail
Survey Target	Information is collected based on household (not per person) in a specific region (in SA)
Meals	Any food consumption or meal in a day
Time period	24-hours, 3 days, 5 days (Exclusive)
Food groups	16 food categories
Crops	Local crops only mapping for vegetables in food categories

Food Survey



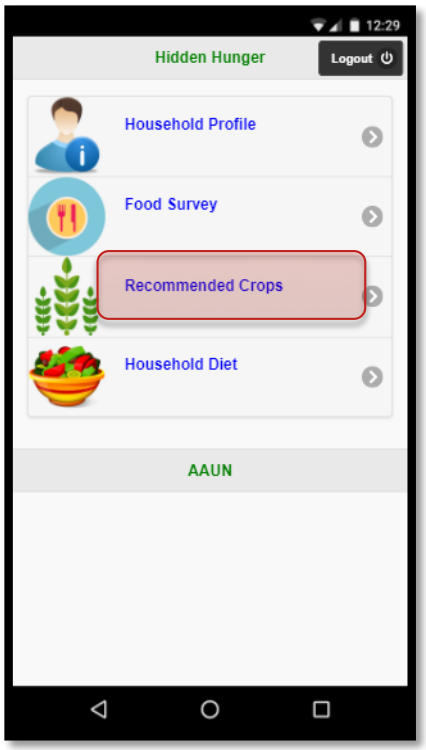


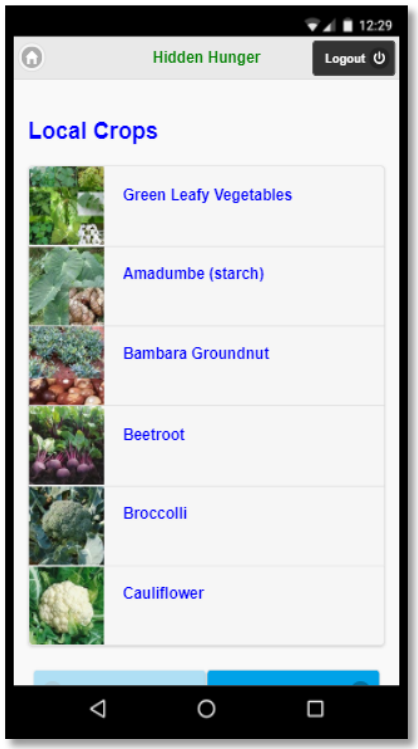


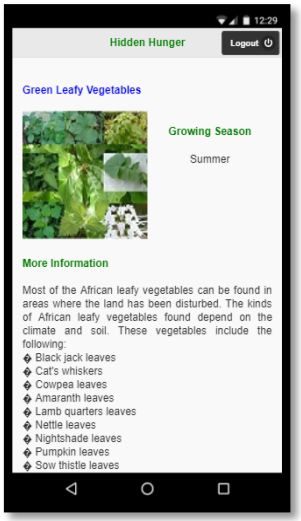


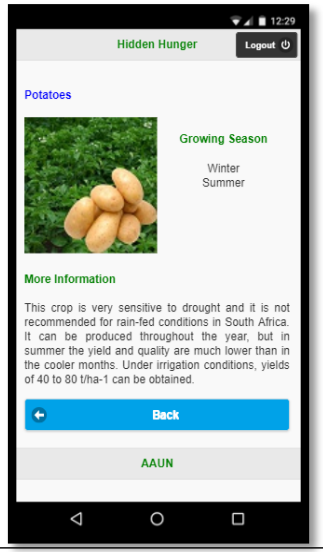
Food Group	Used
Cereals	✓
White Roots And Tubers	X
Vitamin A Rich Vegetables And Tubers	X
Dark Green Leafy Vegetables	✓
Other Vegetables	✓
Vitamin A Rich Fruits	X
Other Fruits	✓
Organ Meat	X
Flesh Meats	X
Eggs	✓
Fish And Seafood	✓
Legumes, Nuts, And Seeds	X

Recommended Crops
(Local Crops)









Data Analysis
(back end)

AAUN

Filter

Date From

Date To

OR

Select No. Of Days

Last 24 Hours

Food Groups

All

Region

All

Display

Date : Jan 28 2018 > All Food Groups > All Regions

Total No. of Users: 2

Food Group	Households Consumed	Households Did Not Consumed
Cereals	50%	50%
White Roots And Tubers	50%	50%
Vitamin A Rich Vegetables	100%	0%
Dark Green Leafy Vegetables	50%	50%
Other Vegetables	100%	0%
Vitamin A Rich Fruits	50%	50%
Other Fruits	50%	50%
Organ Meat	100%	0%
Flesh Meats	0%	100%
Eggs	50%	50%
Fish And Seafood	0%	100%
Legumes, Nuts, And Seeds	100%	0%
Milk And Milk Products	0%	100%
Oils And Fats	0%	100%
Sweets	100%	0%
Spices, Condiments, Beverages	50%	50%

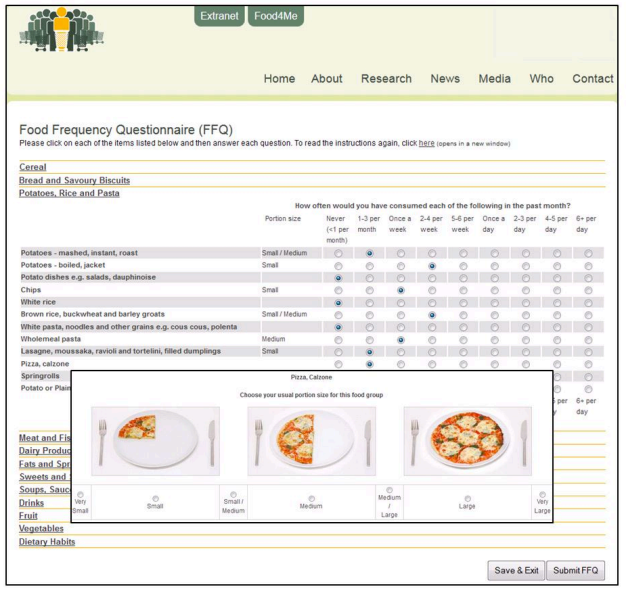
AAUN

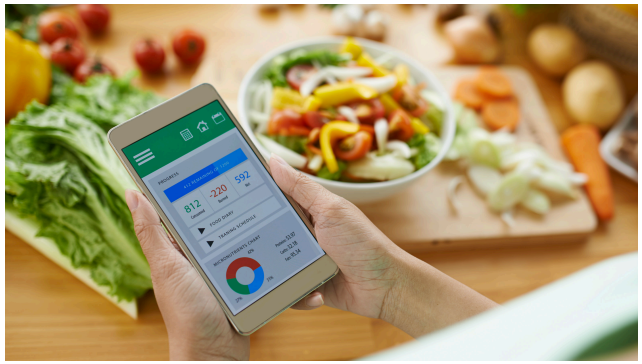
User Management

Logout

Nutrition Monitoring System

- Manual methods
  - 24 hour recalls
  - Food frequency questionnaires
  - Smartphones
- Issues
  - Participants burden
  - Imprecise
  - Low completion rate (~15%)



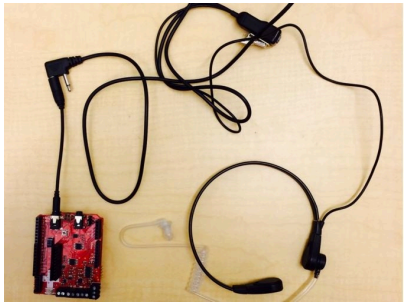


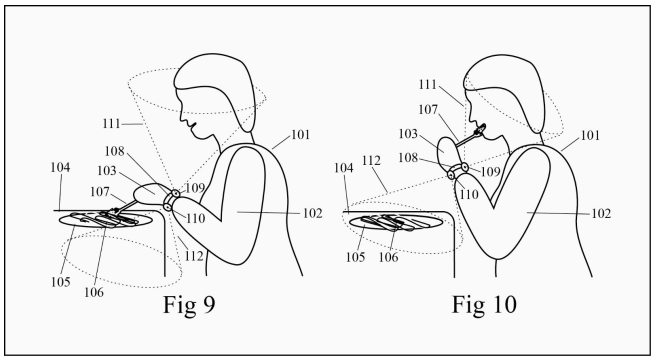
Nutrition Monitoring System

- Automatic methods
  - Sensor-based
  - Environment sensors
  - Removing the participant burden
- Issues
  - Imprecise (lack of food detection)
  - Not practical for free-living style
  - Privacy

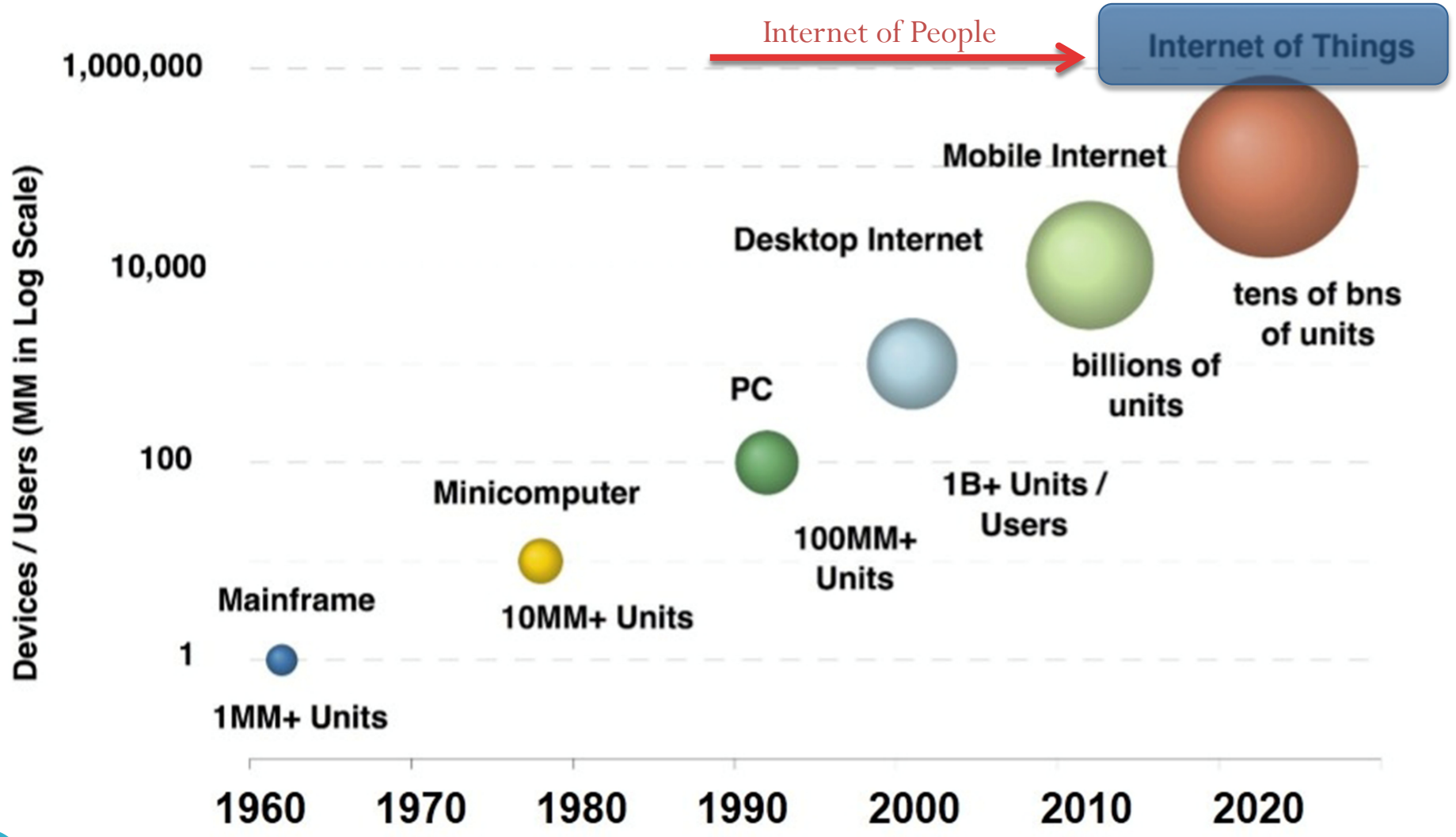
Nutrition Monitoring System

- Automatic methods
  - Sensor-based
  - Wearable sensors
  - Real time food intake monitoring
- Issues
  - Average accuracy of 90%
  - Only tested in lab environments
  - Single dimension





More Connected Devices on the Planet Today Than People



Internet of Things Applications

Smart Grid

Safety Security

Connected Home

Building Automation

Lighting Control

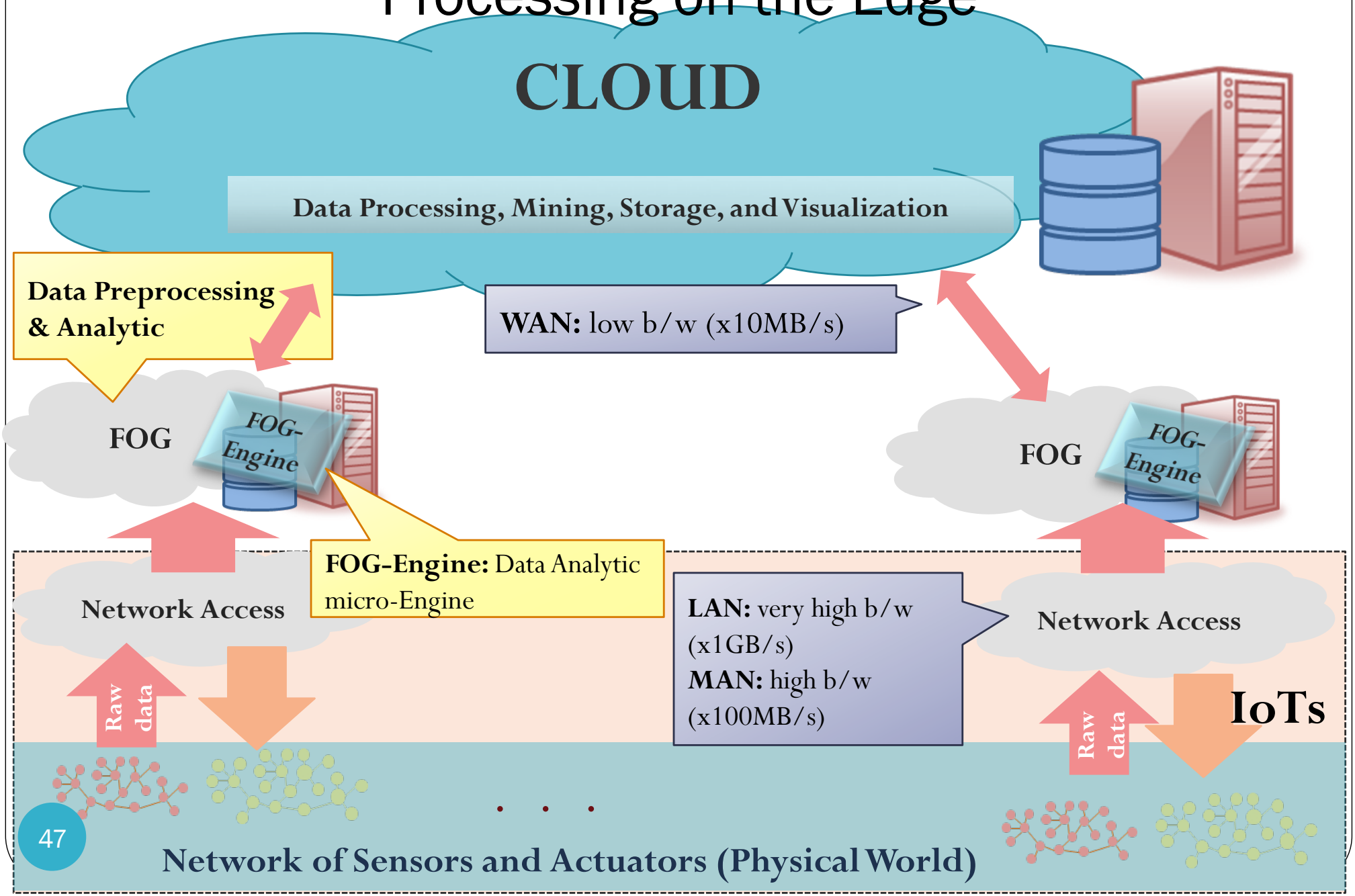
Smart Devices

Health Fitness

Smart Nutrition Monitoring System

- Non-invasive
  - Minimizing the amount of direct input and actions from users
- Project Scope
  - Take away food
- High data accuracy and reliability
  - Heterogeneous IoT sensors
- Scalability
  - Cloud and Fog Computing

FOG-Engine: Decentralized Hierarchical Big Data Processing on the Edge

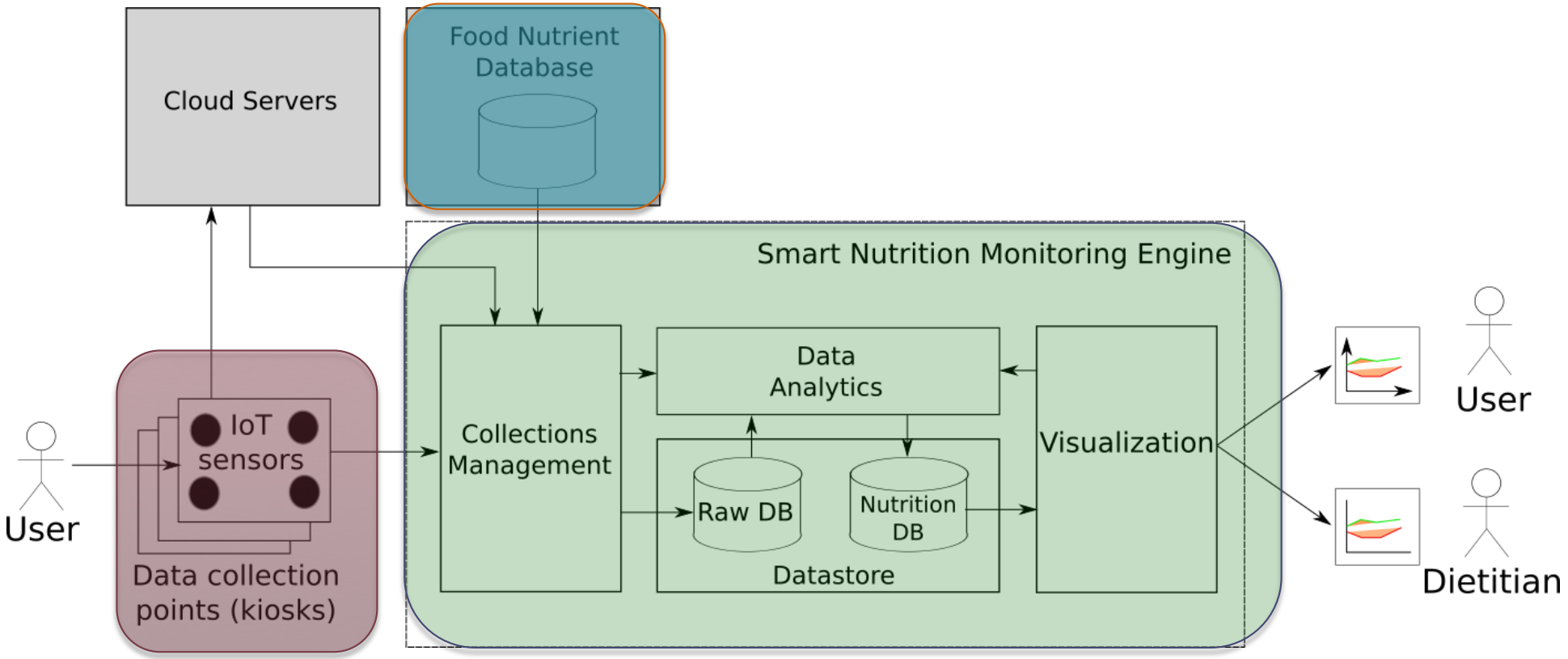


Fog Computing

- **The Fog**
  - extends the cloud computing paradigm to the edge of the network,
  - enables a new breed of applications and services
  - an appropriate solution for the applications and services that fold under the umbrella of the IoTs.

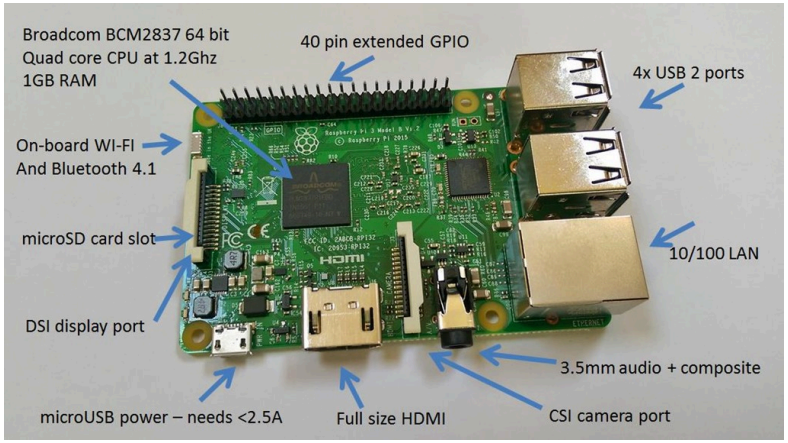
- **Benefits**
  - low latency
  - location awareness
  - widespread geographical distribution
  - mobility support
  - the strong presence of streaming and real-time applications
  - heterogeneity

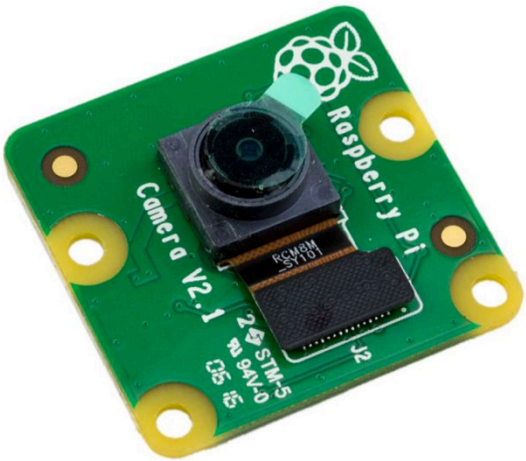
Architecture of Smart Nutrition Monitoring System

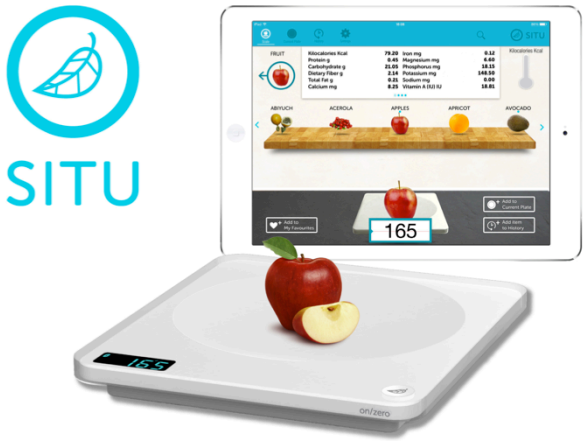


IoT Components

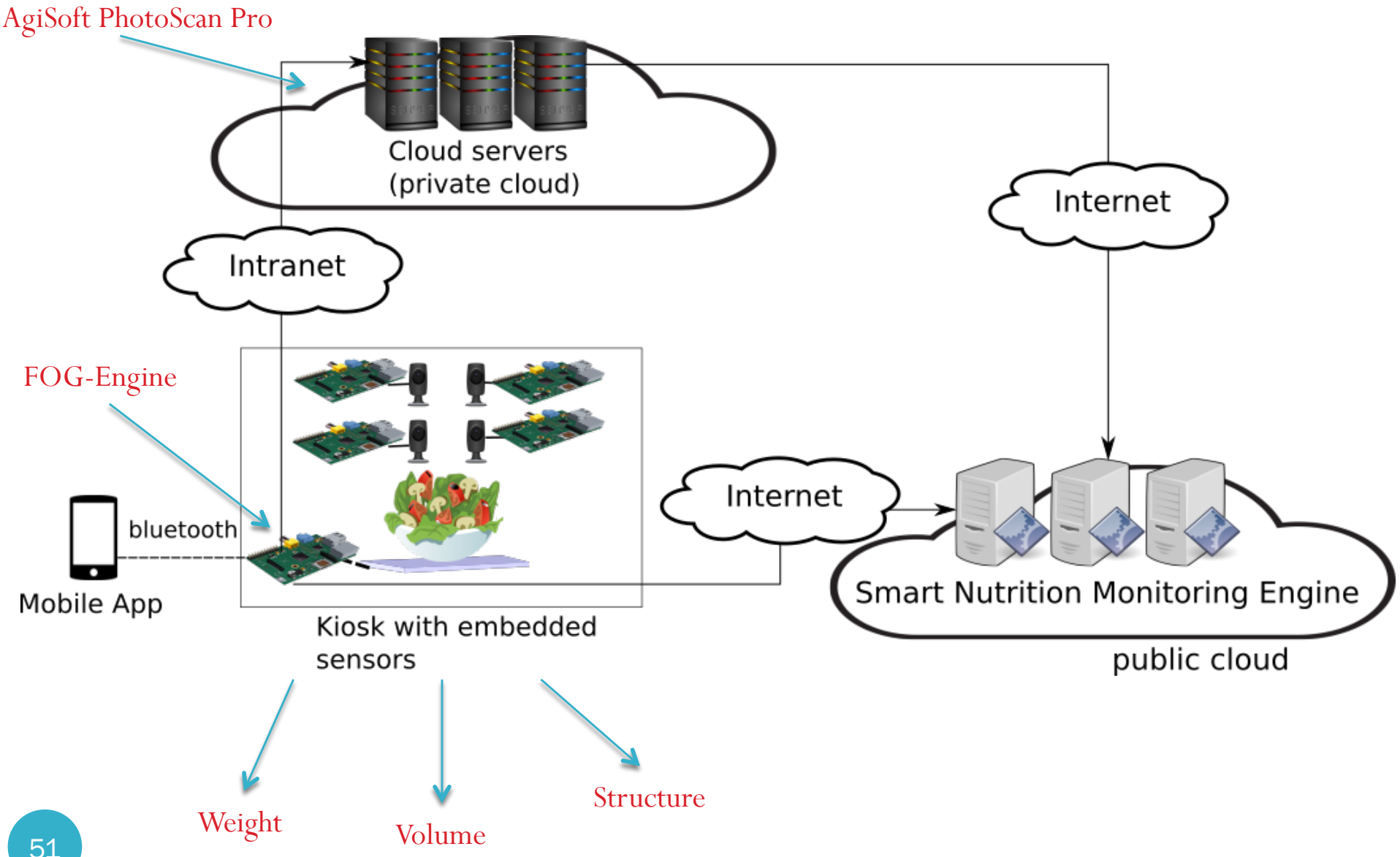
- Raspberry Pi 3.0 x 6
  - emteria OS
- 8MP Camera x 5
- Smart Scale x 1



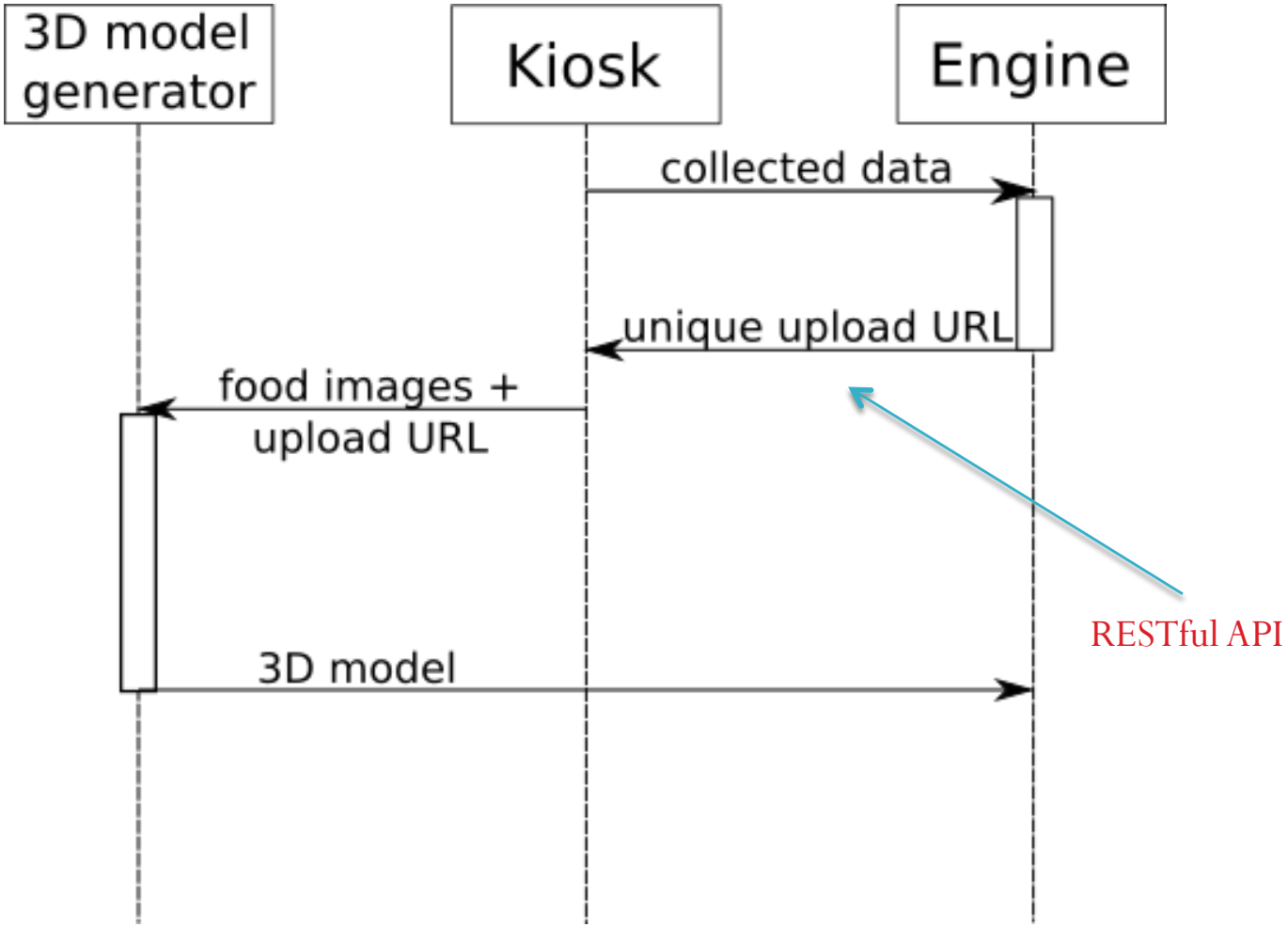




System Prototype



System Interactions

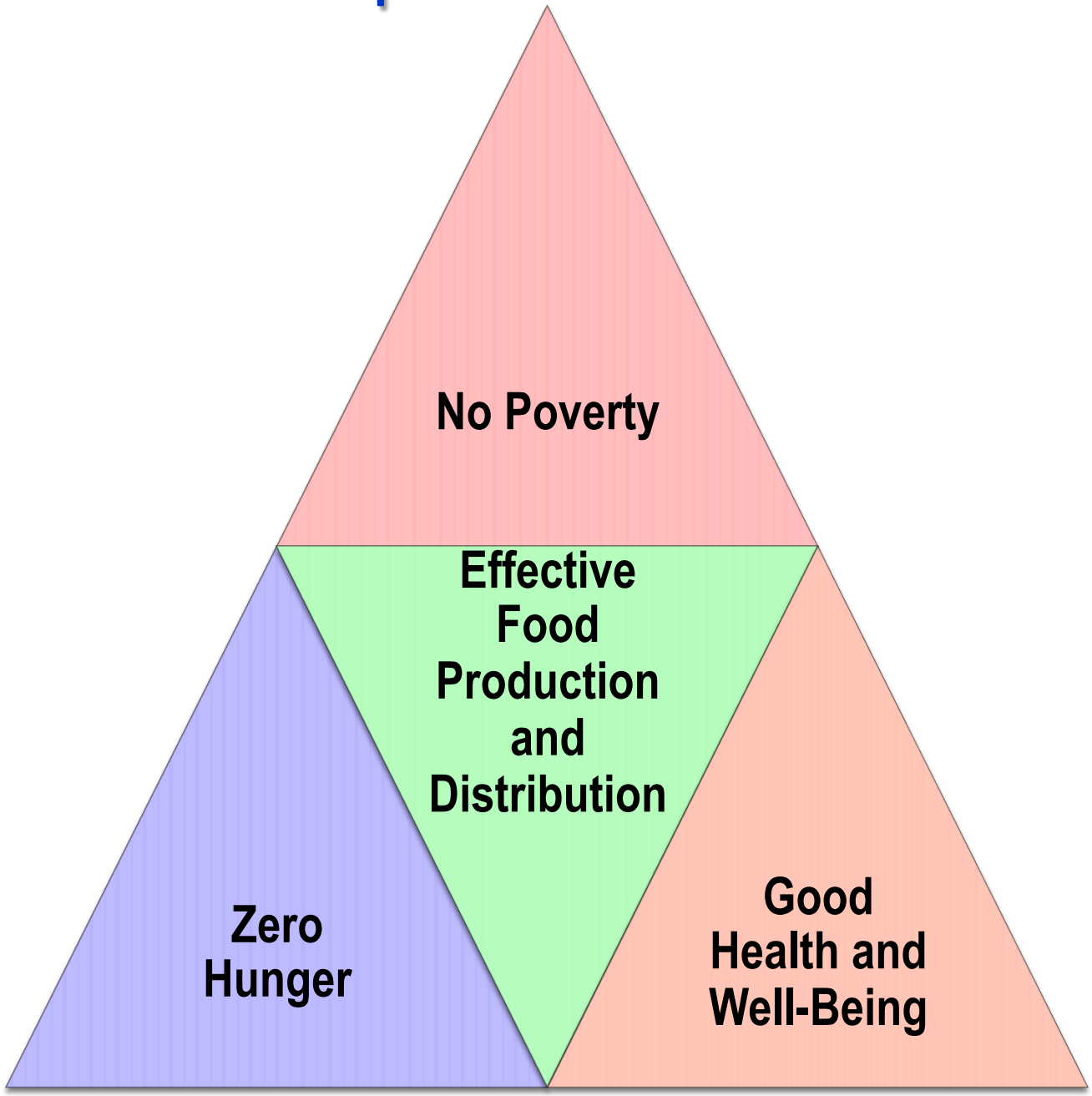


Conclusions and Future Works

- Smart nutrition monitoring system
  - Heterogeneous IoT sensors
  - Non-invasive
  - Utilizing Fog-engine

- Future works
  - Innovative Machine Learning for food detection and food classification
  - System validation and verification (by dietitian)

Sustainable Development Goals



Thank You