From Data Analysis to Internet of Things

A Top-down Perspective for Agriculture And Automatic Hydroponic System

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About **HUST**

HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

- Established in **1956**
- **45.000** students
- **2000** employees, including 1600 faculty members
- **27** schools and research institutes
- **One of the leading** technical universities in Vietnam

Contents

- Why driving forces from Data Analysis to Internet of Things?
- Concepts:
  - Data Analysis
  - Internet of Things (IoT) for data controlling/actions
- Collaborate Research: Automatic Hydroponic System

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Why driving forces from Agricultural Data Analysis to Internet of Things?

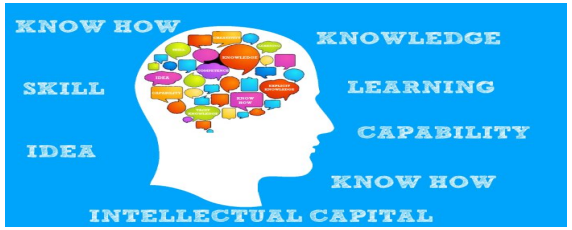
- The transition from the traditional agricultural economy to the knowledge-based, information agricultural economy

Traditional agricultural economy	Knowledge-based and information agricultural economy

• Based on financial capital
  • Capital → production → capital
	• Based on intellectual capital
	  • Capital → information/knowledge → capital

• Focuses on
  • slow moving, rigid organizations, more local scope
	• Focuses on
	  • rapid evolution, innovation, high efficiency, global scope

Financialcapital



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The Role of Information and Knowledge for Agriculture

- Information and Knowledge are the core of:
  - High-technology agricultural goods and services:
    - ◇ Agricultural information and communications technology and services etc.
  - Science-based agricultural economy sectors:
    - ◇ Smart agriculture, Smart Farming, Smart Greenhouse
    - ◇ Smart livestock raising
  - Productivity gains
  - High-skilled labor forces - Building new System:
    - ◇ Collects Data
    - ◇ Analyzes for Information and Knowledge
    - ◇ Controls
    - ◇ based on IoT technologies

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Which Agricultural Data? Where from? What for ?

- Different types of Data:
  - Environment Data: Air temperature, humidity levels, pH level, soil humidity…
  - Growing, condition process of crops or flowers…
- Collected from:
  - Sensors, cameras, mobile devices…
  - Satellites, GPS system
- What for:
  - Analyze for Information – Knowledge
    - ◇ Worker records, production History, prediction of dieseas
    - ◇ Optimization
  - And make Decisions/Actions for:
    - ◇ Optimizing the soil preparation, watering, herbicides, insecticides... processes
    - ◇ Increasing harvest per unit data
    - ◇ Increasing food production capacity data

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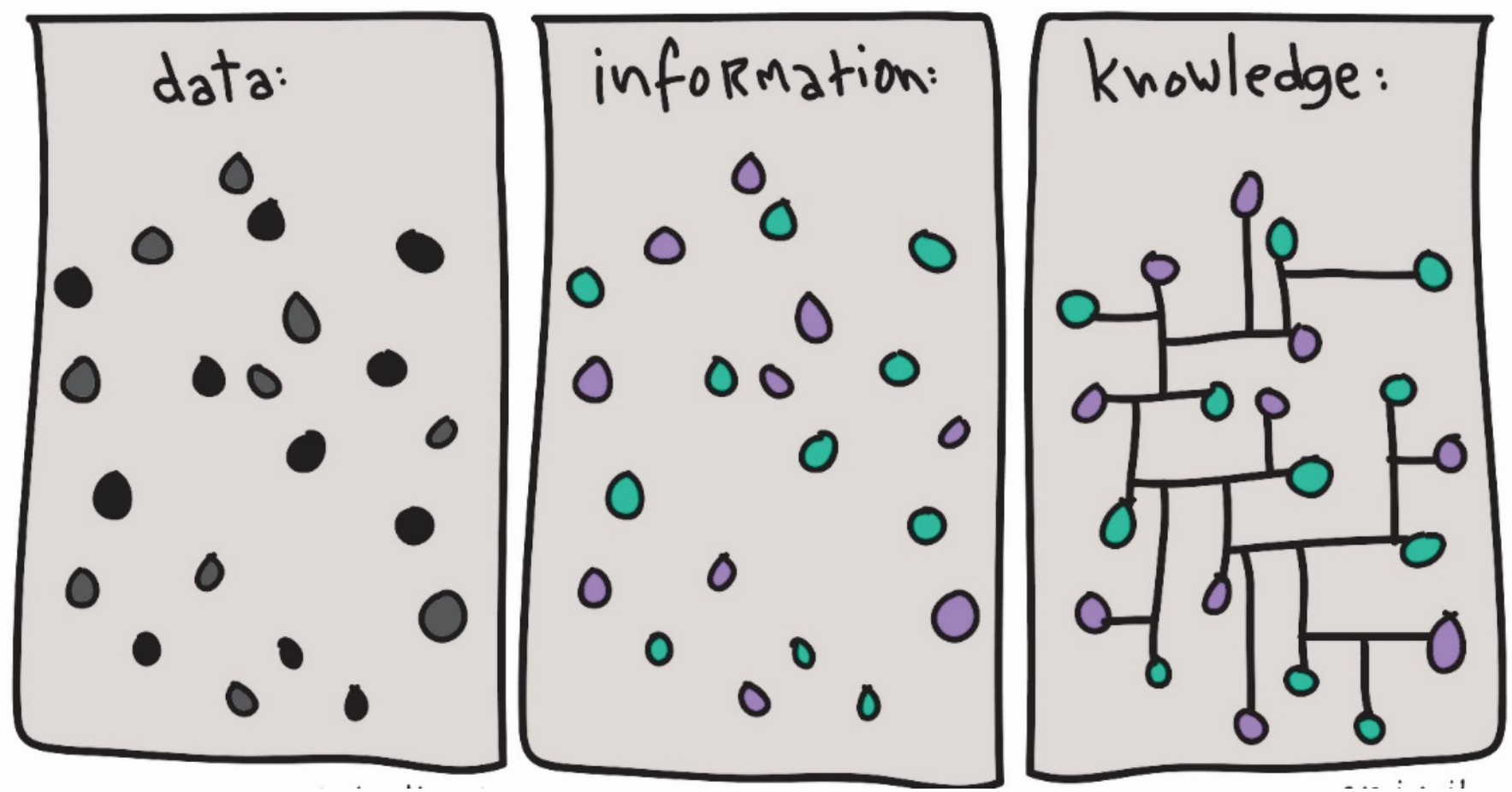
How to Make Agricultural Data Valuable?



Alignment between business objective and data

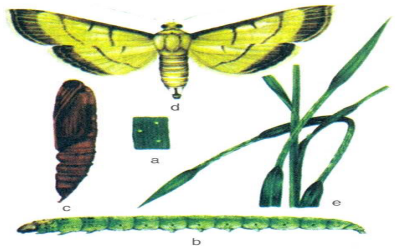
(Source: Julien Blin)

Example in Agricultural Sector

Collecting Agricultural Data

Analyzing Data

Analyzing Data for Knowledge:
Detecting Objects



Analyzing Data for Knowledge
Anomaly Detection

Knowledge:
Identification of Anomality

Storage
in Database

Controlling Decision:
Insecticides

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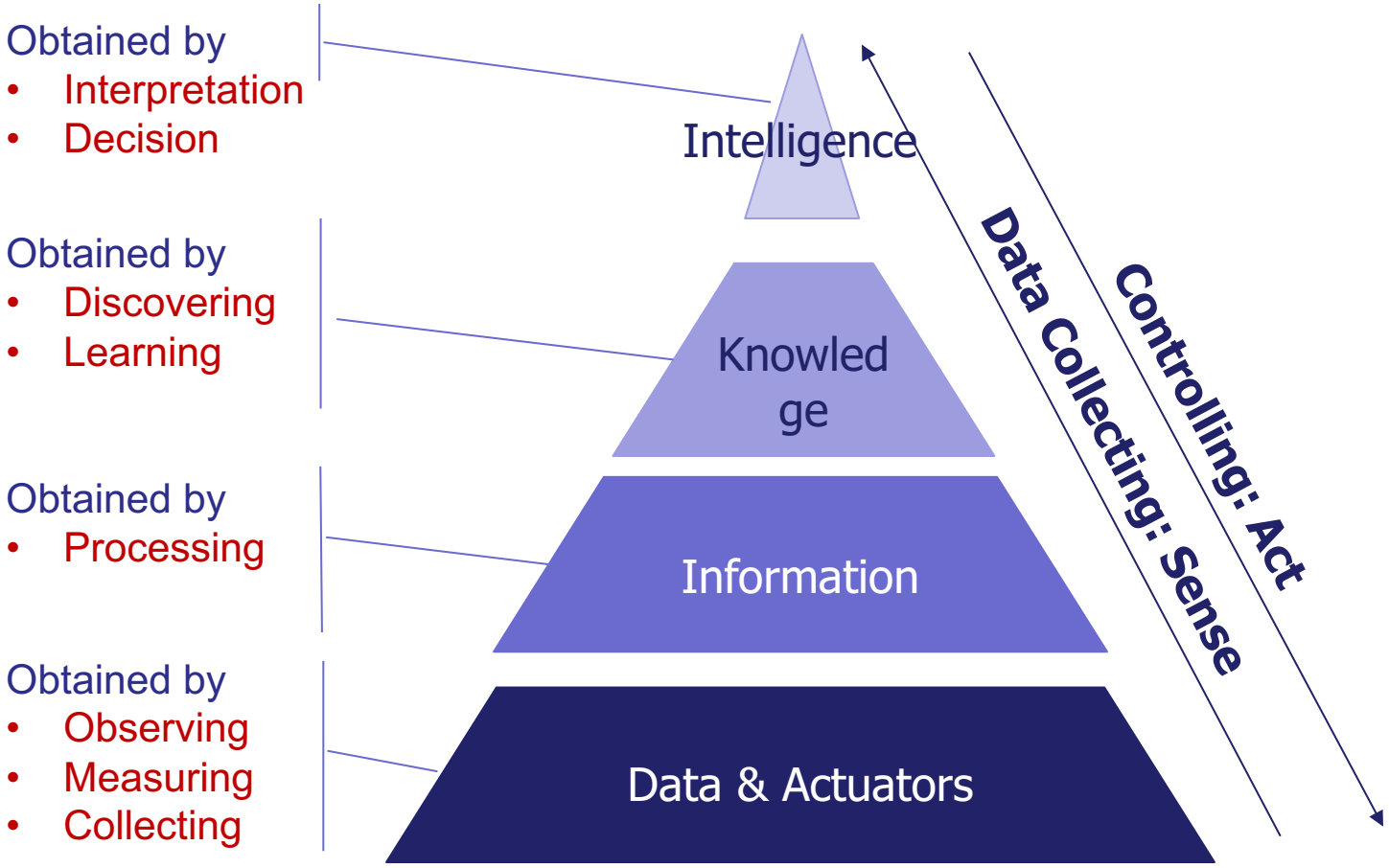
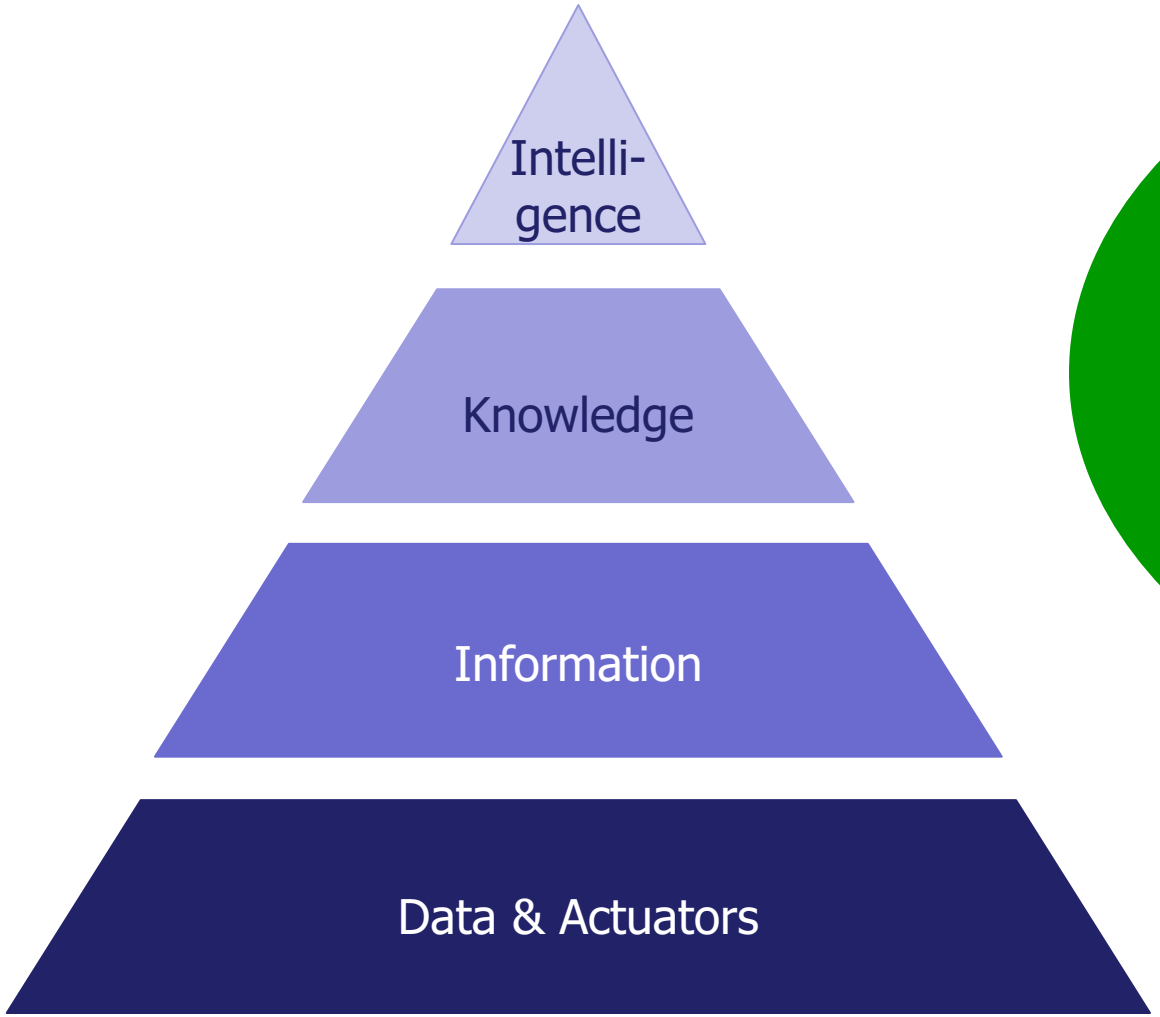
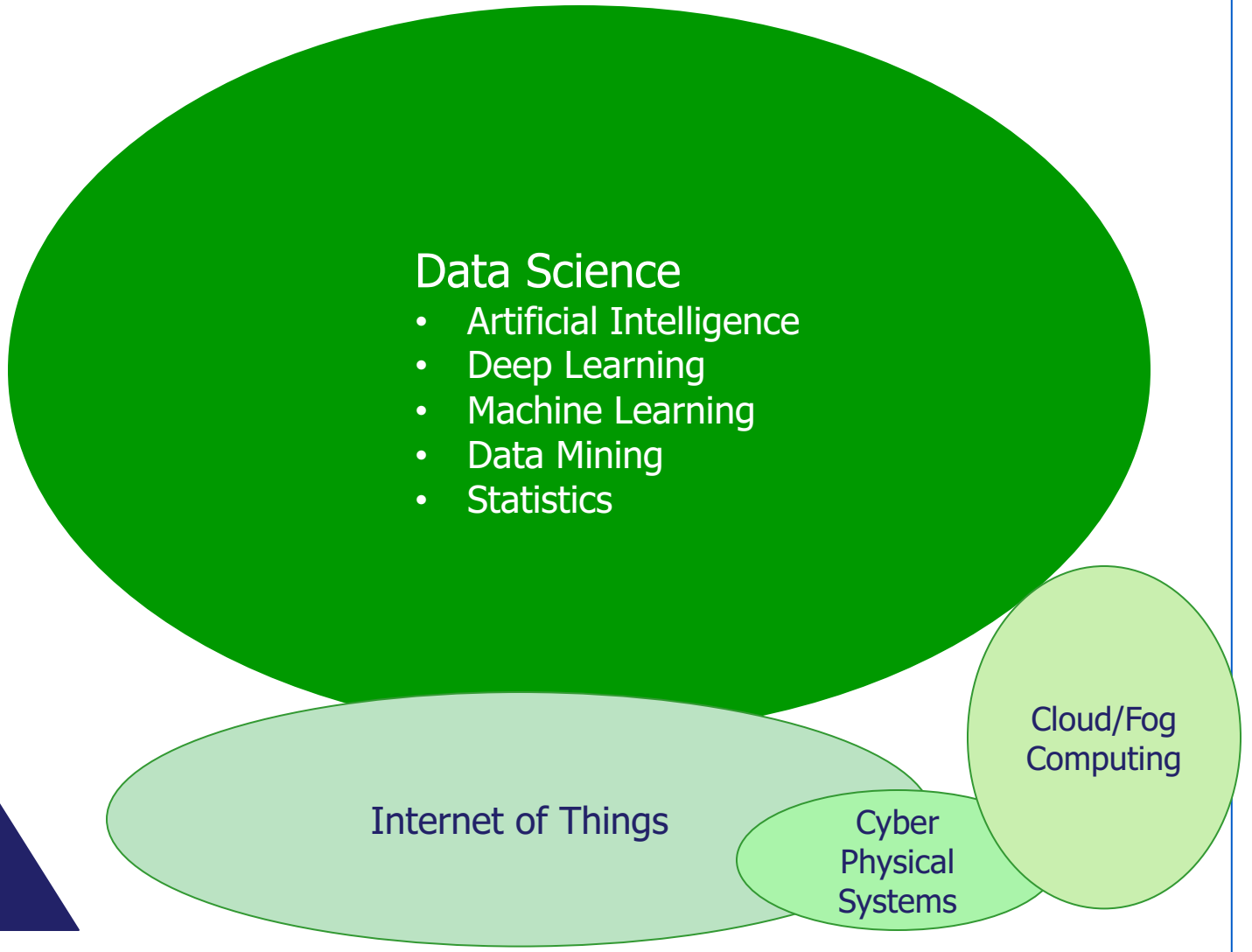
Data – Information - Knowledge



- Interpretation, optimization and evaluation
- Data analysis
- Data preprocessing, modelling and transformation
- Data collection and control

Data – Information - Knowledge





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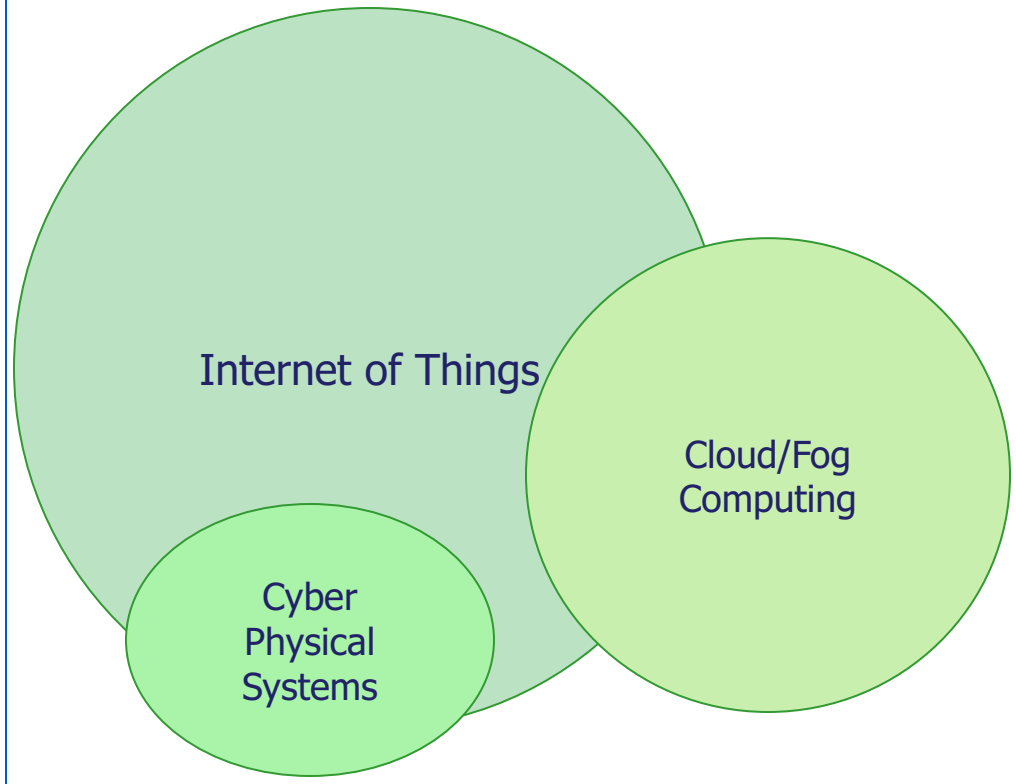
Internet of Things (IoT) for data collecting/controlling



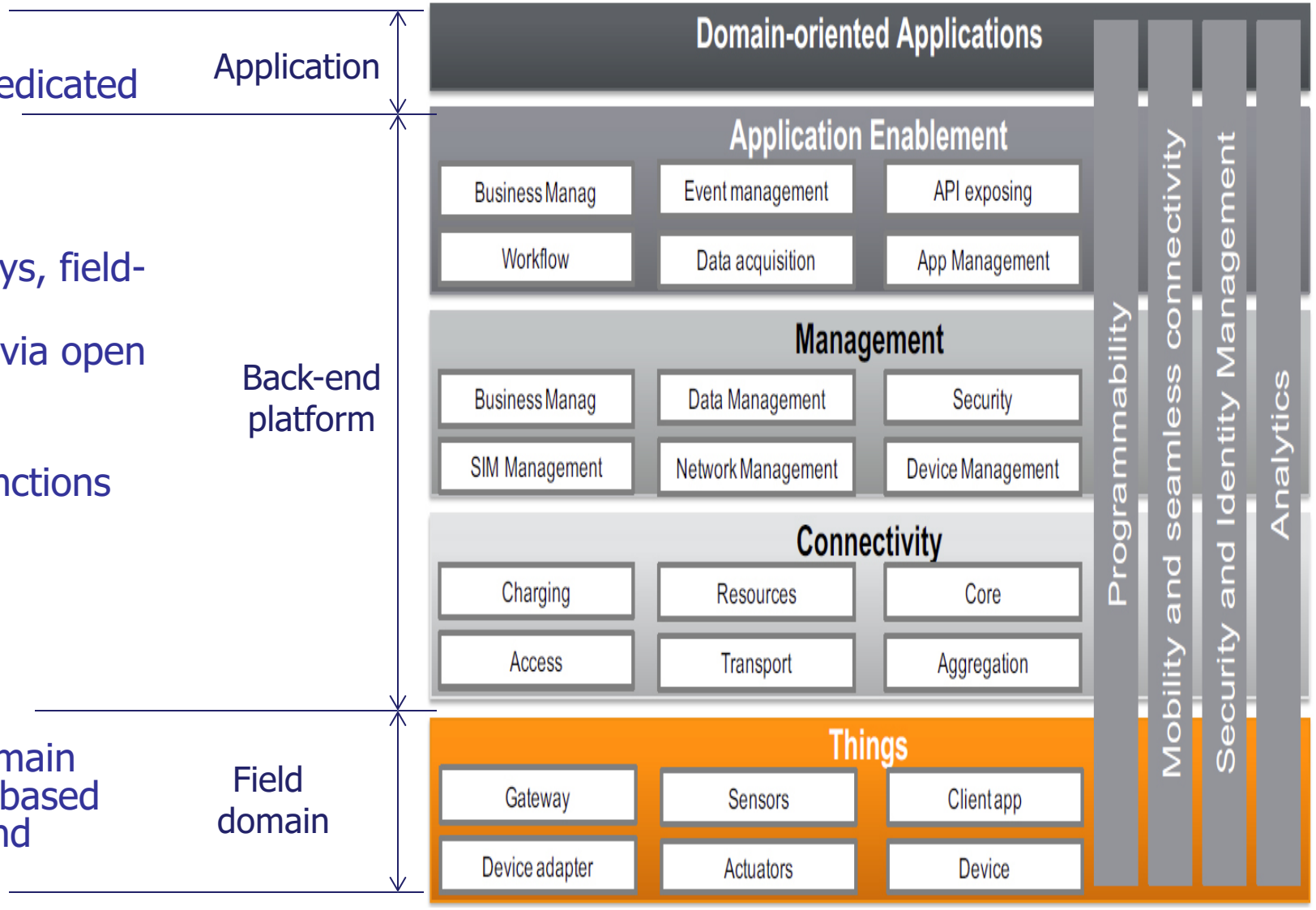
- How to collect, transmit, store and preprocess data?
- How to control/do actions?

→ **Internet of Things (IoT):**

  - Providing unified connected environments for converging real and virtual world
  - Facilitating new advanced services by interconnecting things based on interoperable information and communication technologies

Internet of Things (IoT) for data collecting/controlling

- **Application**
  - Providing distinct services to dedicated vertical domains
- **Back-end platform**
  - Aggregating data from gateways, field-domain devices
  - Mediating data to applications via open APIs
  - Managing connections
  - Performing data processing functions and data/device abstraction
- **Field domain**
  - Covers the integration with domain specific sensors and actuators based on their access technologies and interworking protocols



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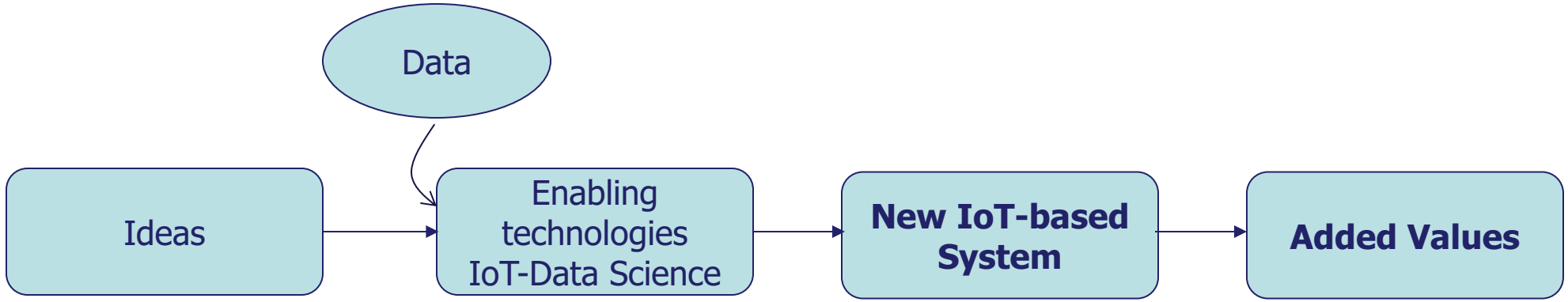
Conclusions

- To collect and make agricultural data valuable, **enabling new technologies are needed:**
  - Data analysis/optimization
  - IoT for collecting/controlling
- In agricultural sector, **helps to build new IoT-based System for Bringing new Added Values**



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Collaborate Research: Automatic Hydroponic System

- **Many vietnamese commercialized solutions:**
  - Have been proposed: HACHI, LISADO…
  - **Only limited** to environment data collecting
  - **Without** data analysis/optimization, controlling/actions
  - → **Not 100% automatically**
    - → Necessary to have intervention of agricultural engineers
    - → Difficult deployment
    - → Limited economic efficiency
- **Other imported automatic solutions:**
  - High price → Difficult to deploy widely

→ **IoT-based AUTOMATIC HYDROPONIC SYSTEM**

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Collaborate Research: Automatic Hydroponic System

- **AUTOMATIC HYDROPONIC SYSTEM:**
  - Water-efficient, low-power, low-cost, automatic
  - **Appropriate to areas with:**
    - ◇ **Limited surface**
    - ◇ **Limited water resource**
    - ◇ **Limited sunlight**
    - ◇ **Where water is salty**
  - **But still bring high economy efficiency**
  - Based on following important functions:
    - ◇ IoT-based Data Collecting/Controlling
    - ◇ Data Analyzing/Optimization
- **2 Models:**
  - House (building) of m2
  - Production Greenhouse of of hundreds m2
- **High economy-efficient crops and flowers:**
  - Kale, salad, spinach, tomatoes…

In House Model

Production GreenHouse Model

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Collaborate Research: Automatic Hydroponic System

- **Requirements:**
  - **IoT-based Environment Data Collecting:**
    - ◇ pH, Co2, temperature, soil humidity: once/min.
      - → **Reliable, Secured and Authenticated Transmission**
  - **Data analysis/optimization for maximizing yield, minimizing production costs:**
    - ◇ Crops growing process, pH, CO2…
      - → **Reinforcement Learning Algorithm based on Markov-Chain**
  - **IoT-based Controlling/Actions: Fan, Watering, LED systems**
    - ◇ Based CO2 level → Controlling fan system
    - ◇ Based on night and day → Controlling LED systems
    - ◇ Based on pH levels, crops growing process → Controlling amount of nutrients and watering system
      - → **Reliable, Realtime, Multi-domains Secured and Authenticated Transmission**
      - → **Traffic - and QoS-aware Transmission**

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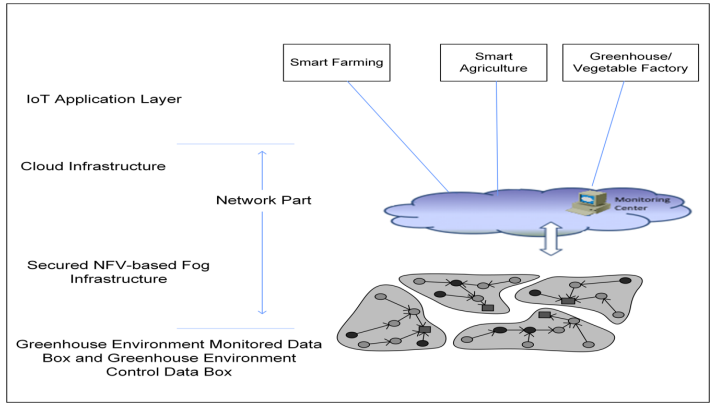
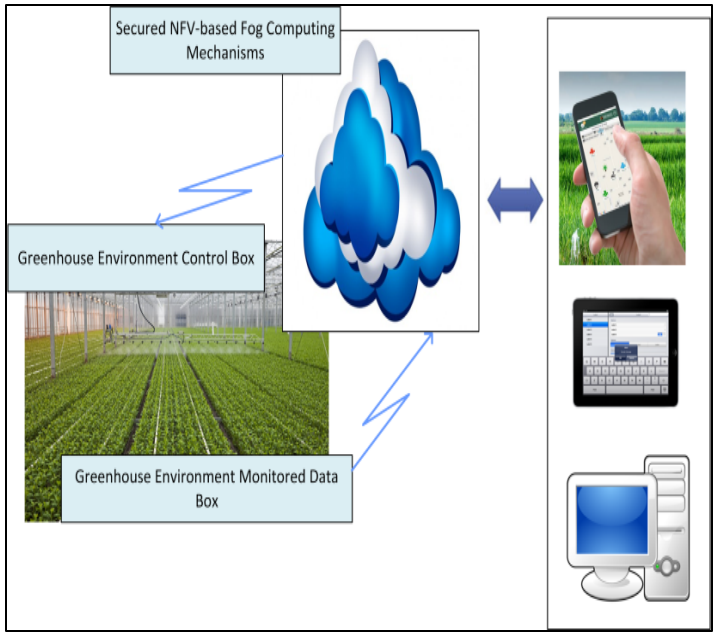
Collaborate Research: Automatic Hydroponic System

- **Solving common social challenge :**
  - Help to produce high economic-efficient crops and flower
  - In area with limited surface, limited water and sunlight resource, water is salty
- **By focusing on following research areas:**
  - Reliable, real-time, secured and authenticated, traffic- and QoS-aware data transmission/controlling
  - Reinforcement Learning Algorithm for Optimization based on Markov-Chain
  - Developing demo testbeds for 2 models
- **And by establishing research collaboration between:**
  - Japan: NICT, helping us to realize this idea
  - Vietnam: HUST;
  - Collaborate Partner: Champasak University at Lao
  - **Activities: Joint seminar, workshops, collaborate publications**





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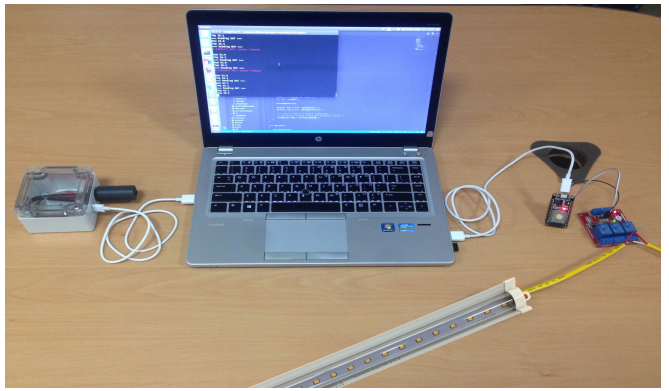
Collaborate Research: Automatic Hydroponic System

- **Equipments:**
  - **Low-power, low-cost Hardware Sensors:**
    - ◇ ARDUINO Mega, RE-Mote (Zolertia), ESP32
    - ◇ Operating Systems: ARDUINO IDE, Contiki, FreeTOS
  - **Sensing Components:**
    - ◇ Humidity, temperature: RTH03 (from Zolertia)
    - ◇ pH, CO2
  - **Actuators:**
    - ◇ **LED:** from Rangdong company
    - ◇ **Fan:** IFAN/A
    - ◇ **Watering system:** 4 KAMOER 12VDC
- **IoT-based transmission technologies:**
  - CoAP/UDP/IPv6/6LoWPAN/802.15.4; MQTT/TCP/IP/802.11n
- **Already implemented at HUST:**
  - ◇ 1 ESP32 for monitoring temperature, humidity
  - ◇ 1 ESP32 for monitoring pH, CO2
  - ◇ 1 ESP32 for controlling (fan, LED, watering systems)
  - ◇ MQTT/TCP/IP/802.11



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Related Result, received from 2 current IVO Projects

- **HUST is current member of 2 IVO Projects (Mar. 2016-Mar. 2018)**
  - Mobile IoT and IoT Open Innovation Platform
- **Result received from these projects: Successful design, simulation and implementation of:**
  - ◇ **CoAP/UDP/RPL-IPv6/6LoWPAN/802.15.4 on ARDUINO MEGA**
  - → **Contribute to all IVO members who want to build their own Eco-systems**
  - ◇ Traffic-aware Communication Protocol based on Reinforcement Learning for 802.15.4e
  - ◇ QoS-aware Communication Protocol based on Orchestra Scheduler of 802.15.4e
  - ◇ Monitoring and Notifying IoT-based system based on MQTT/TCP/IP/802.11 on ARDUINO MEGA, Mosquito MQTT Broker and Mosquito MQTT Client

→ **In order to be able to continue to extend this result for Automatic Hydroponic System**

→ **We would like to propose this collaborate research project**

THANK YOU!

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