A Universally Designed and Accessible Indoor Air Quality Monitoring and Warning System

UD-IAQMWS!

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Outline

- Context
- Objectives
- Proposed system
  - Design and development
  - Advantages
- Research method
- Evaluation and results
- Challenges
- Conclusion

Context (1)

Solid Fuels

- What are solid fuels?

Indoor Air Pollution (IAP)

- The 3 Billion people problem
- Type of emissions and pollutants

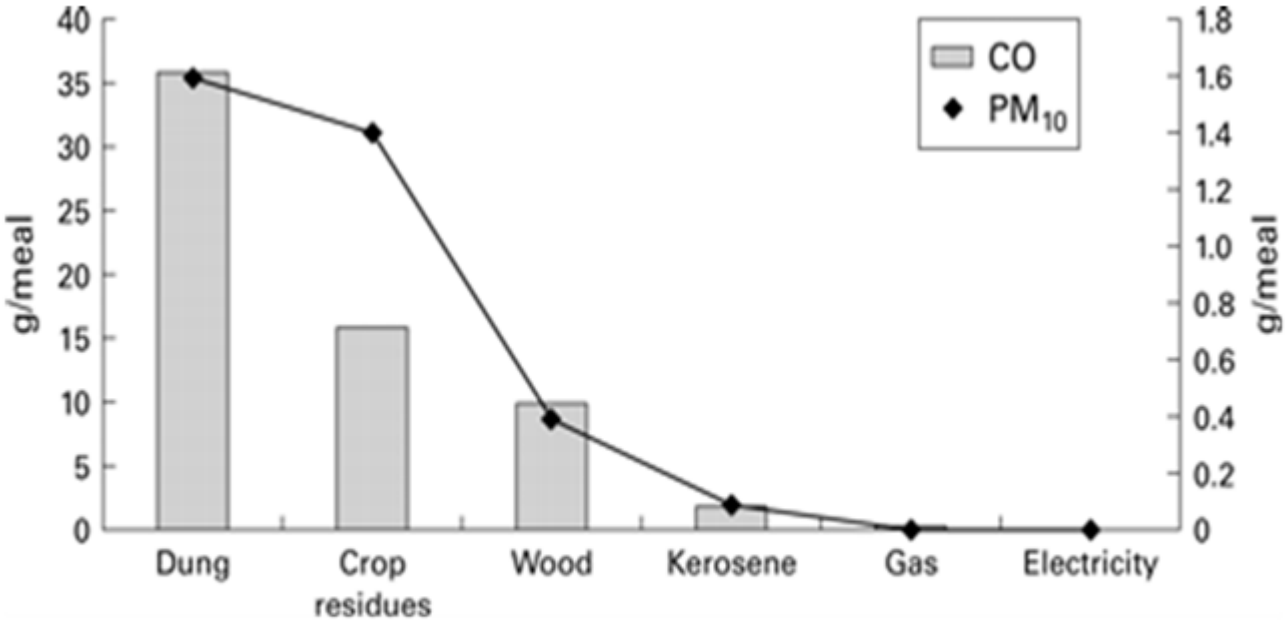


Figure 1: Pollutants by source and level in Most Developing countries (copied from: Indoor air pollution in developing countries and acute lower respiratory infections in children) (Smith, Samet, Romieu, & Bruce, 2000)

Context (2)

Health Effects

- Mortality and Morbidity
- Repertory and Infectious Diseases

Possible Solutions

(In accordance with WHO guidelines)

- Conventional Solutions
- Technology and Innovation

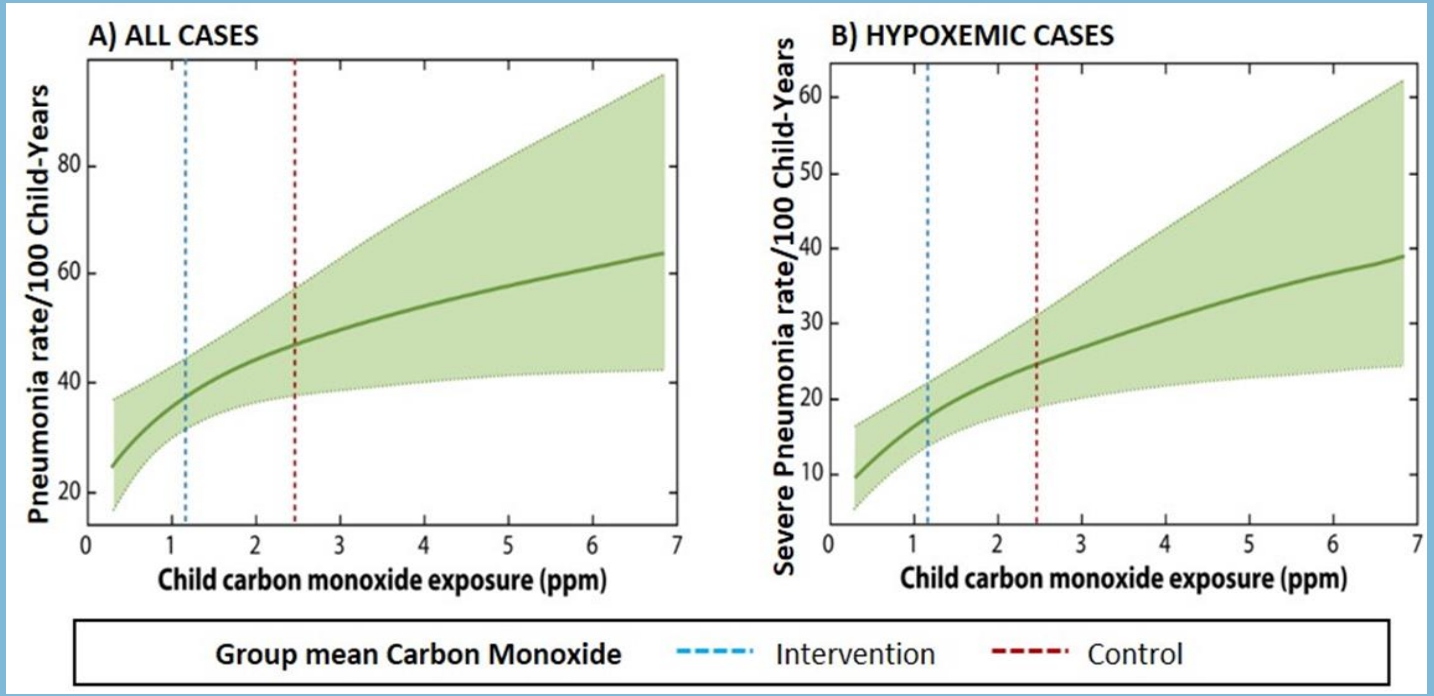
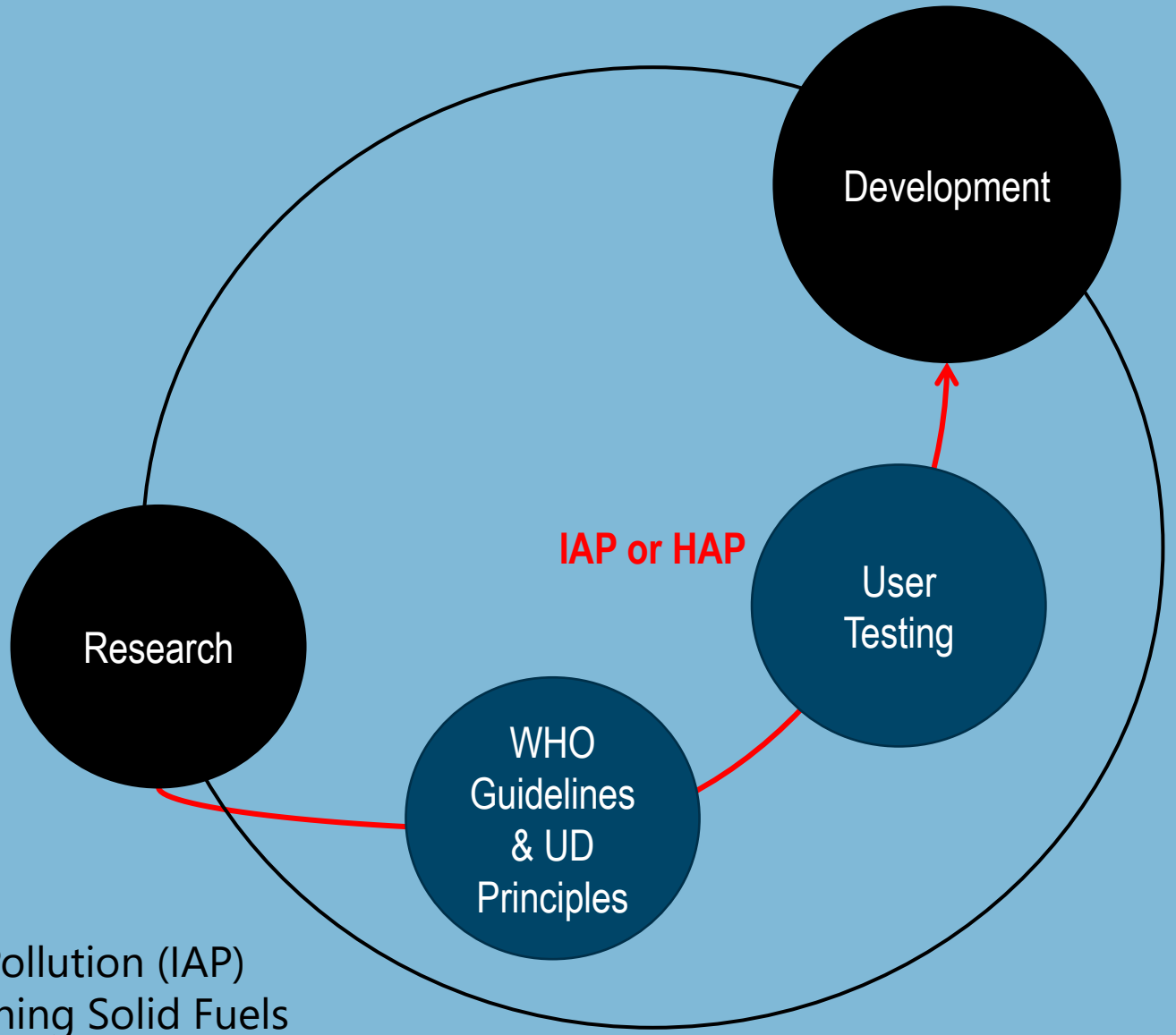


Figure 2. Physician-Diagnosed Pneumonia Due to Carbon Monoxide (Co) Exposure (Source: [2]).

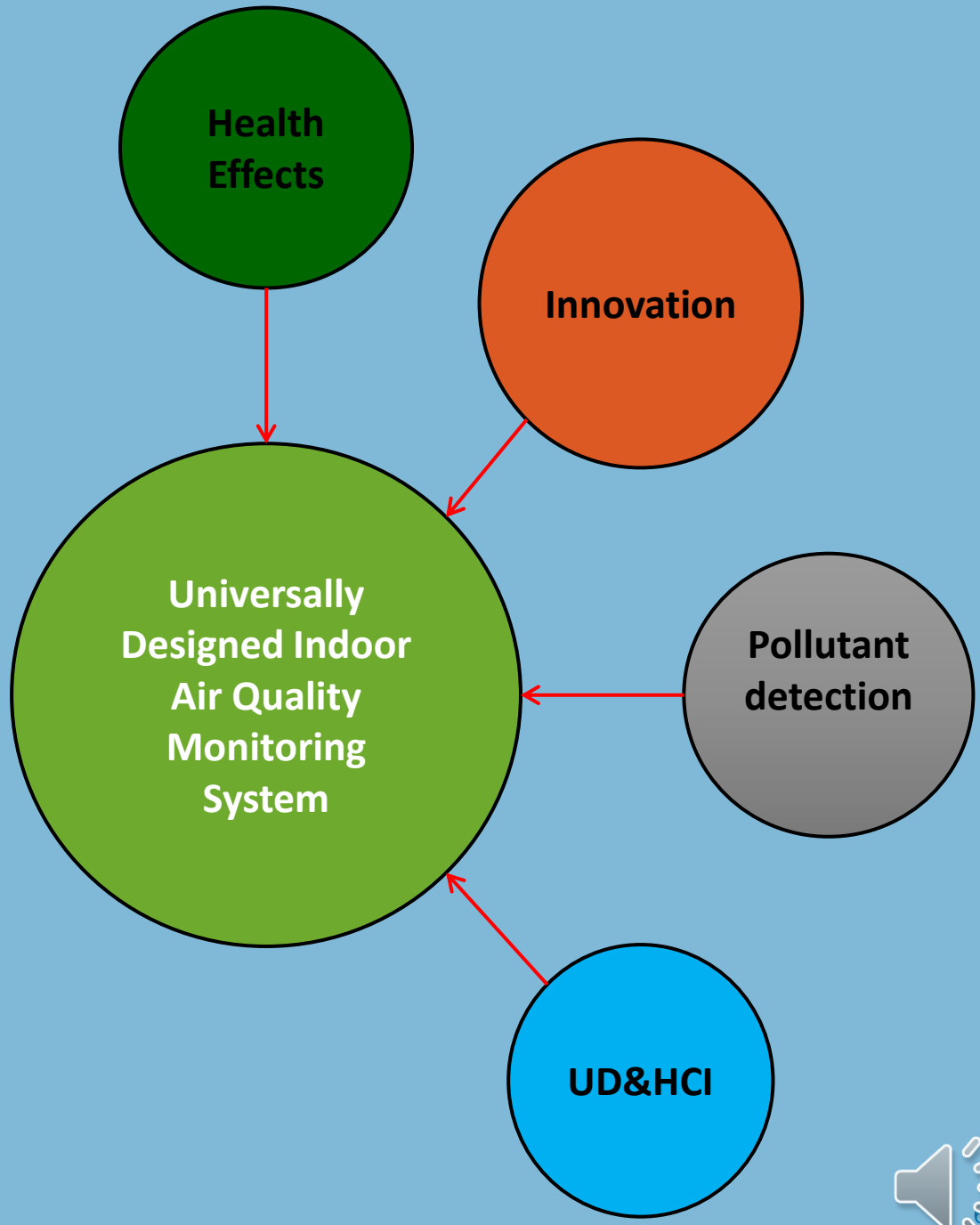
Objectives (1)

An R&D Project leading to the design development and testing of an Indoor Air Quality Monitoring System



Combating the Health Effects of Indoor Air Pollution (IAP) or Household Air Pollution (HAP) due to burning Solid Fuels

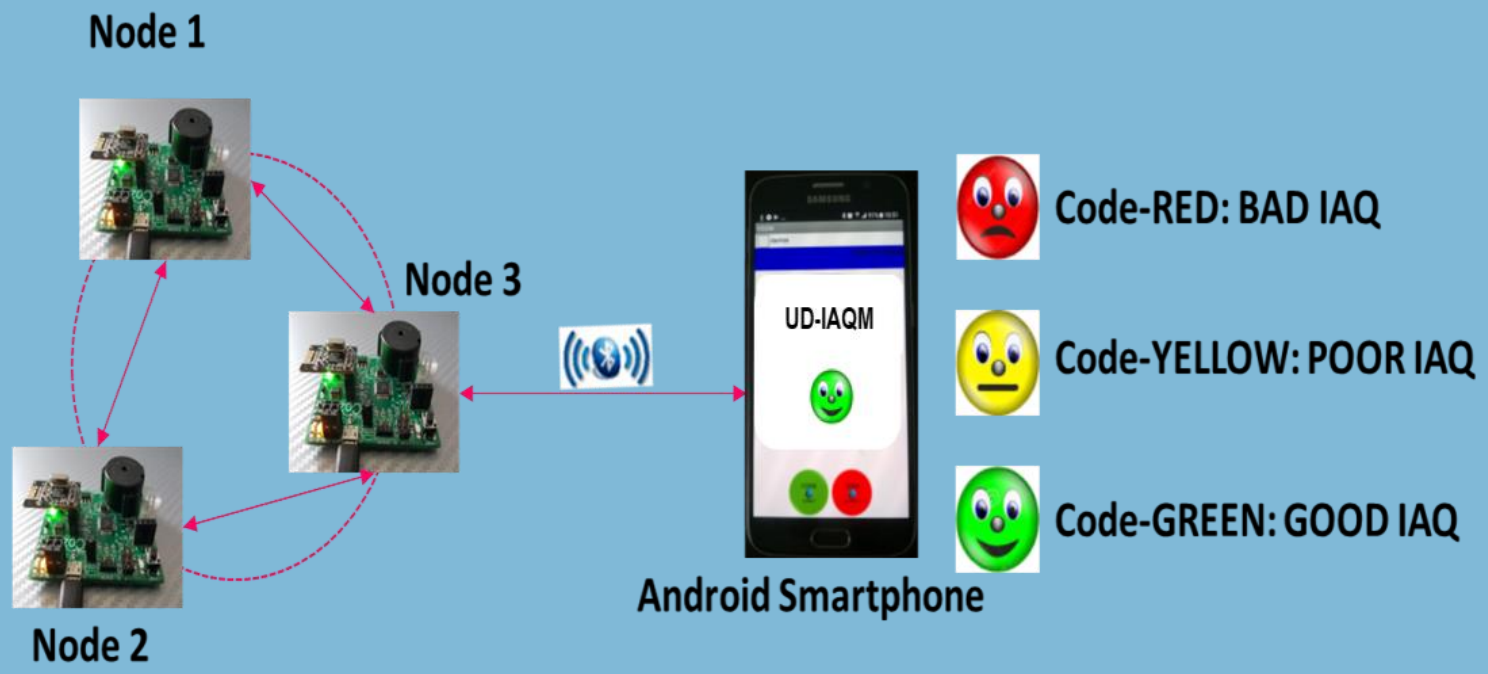
Objectives (2)



Universal Design, Human-Computer Interaction (HCI), User testing, use of Personas , Accessibility and Addressing Disabilities

Proposed System (1)

- Indoor Air Quality (IAQ) Sensor-Node Network for detection and warning.
- The system applies Universal Design (UD) and Integrates the Sensor Network with HCI.

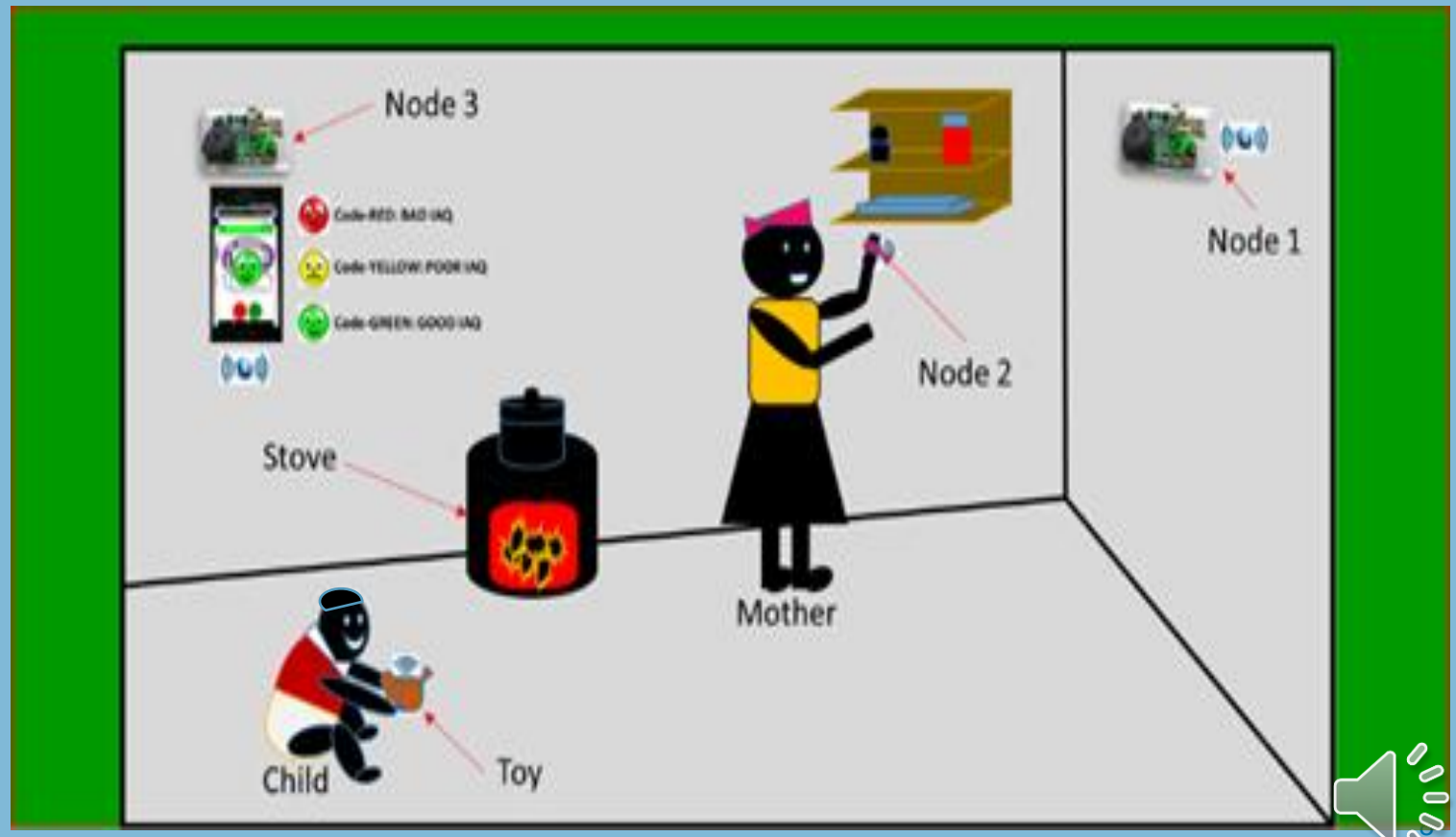


NB: UD-ready Hardware Prototype connects to mobile Platform via Bluetooth Link to a smartphone

Proposed System (2)

- 3 sensor-nodes cover the entire house and cooking area.
- Mother’s wristband or watch demonstrates Wearability.
- Child’s toy Illustrates Portability.

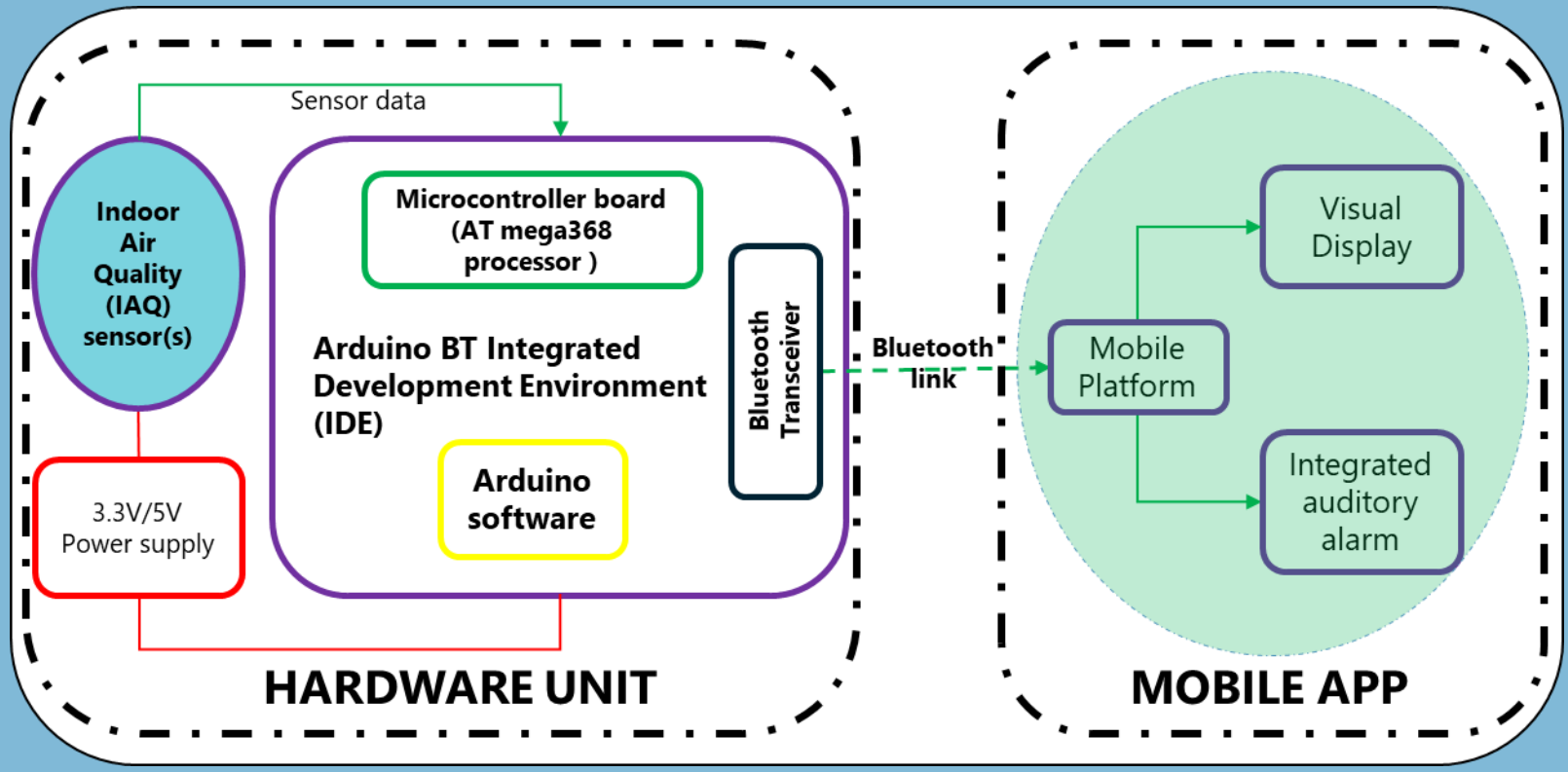
A Typical Real-life Situation



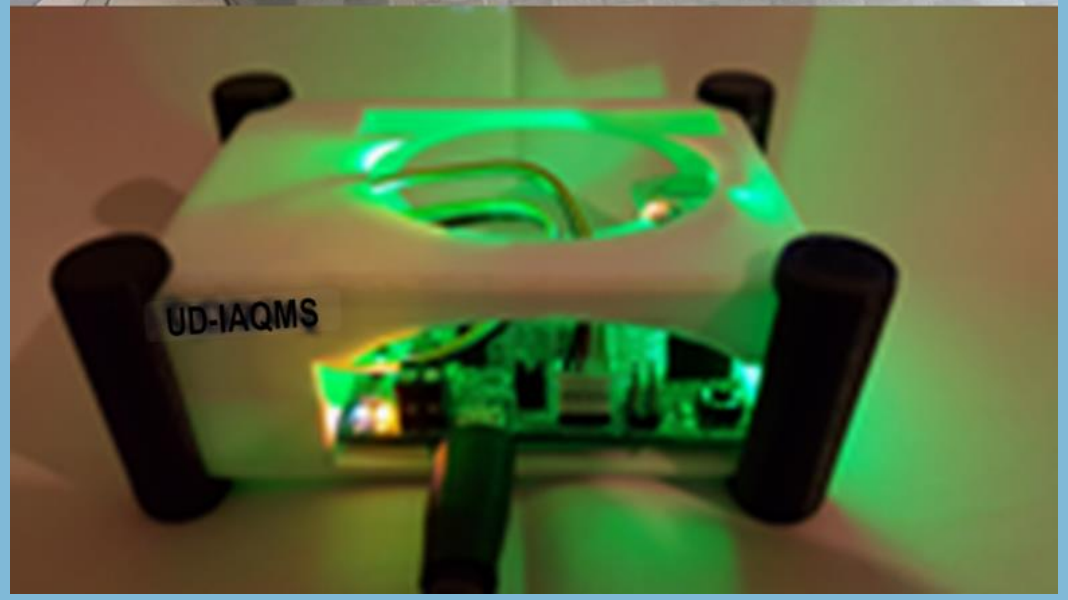
System Design and Development (1)

The hardware, software and mobile app are all built on open-source platforms.

The system is designed to address any user's needs. Users disabilities or impairments, inclusive.



System Design and Development (2)



Simplicity, Flexibility, Portability, and Accessibility guided the system's development throughout the design process.

Advantages (1)

1. Accessibility/HCI

- Built for all
- Utilizes HCI to address child exposure.

2. Multiple feedback

- Offers Visual, Auditory and Tactile notifications to users

3. Multiple sensors

- A network of 3 or more sensor nodes.
- More than one sensor can be connected
- Different pollutants can be detected simultaneously or contrastingly if an oxygen sensor is used in the network.

Advantages (2)

4. Hardware flexibility

- Operates as a standalone-system or networked.
- Users can choose to connect a mobile phone or not.
- Each node can charge its batteries via USB or solar panel.

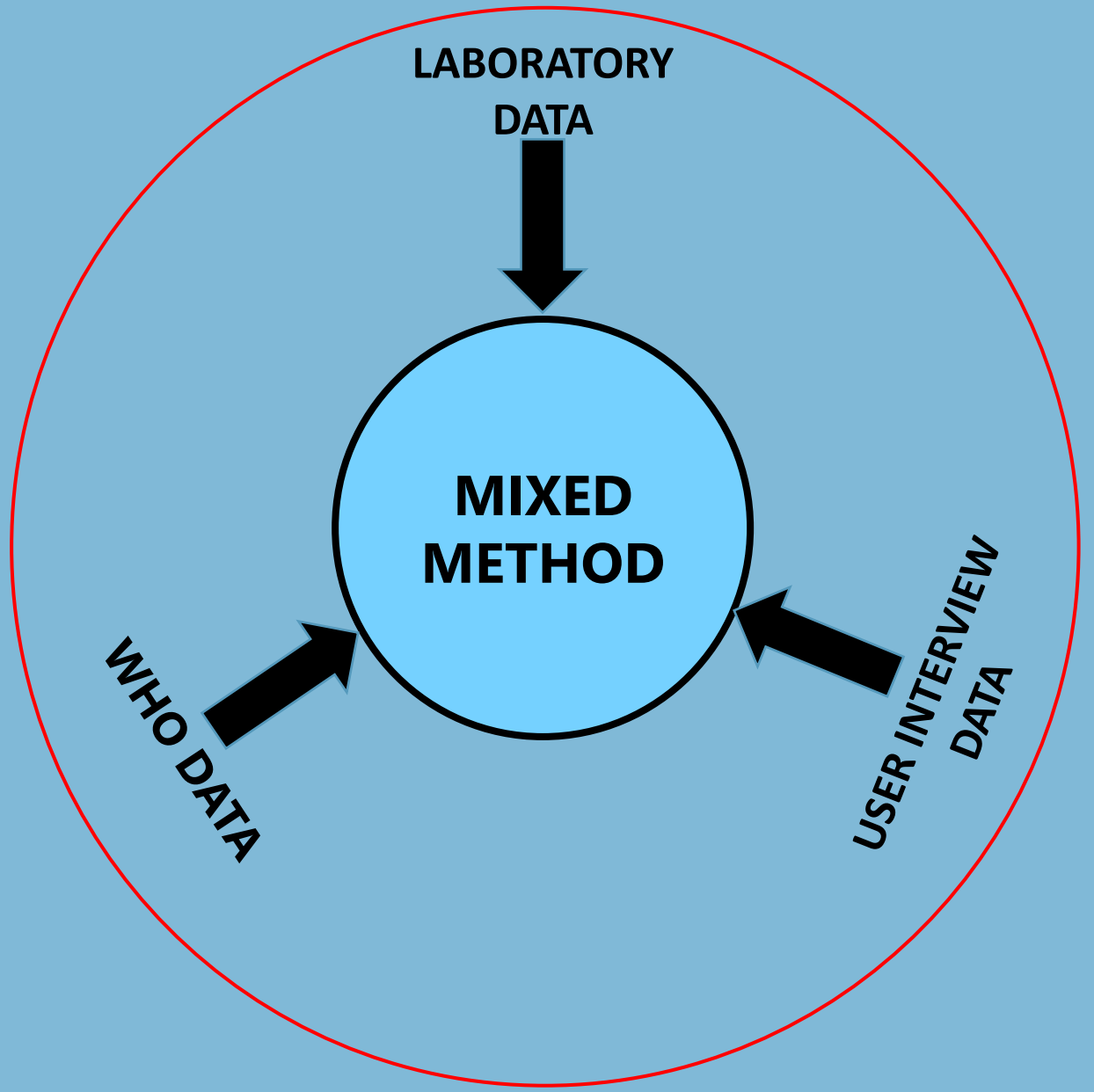
5. The system is UD-compliant

- Complies with at least the first five UD principles
- More accessible to a wide range of users

Research method

Mixed Research Method

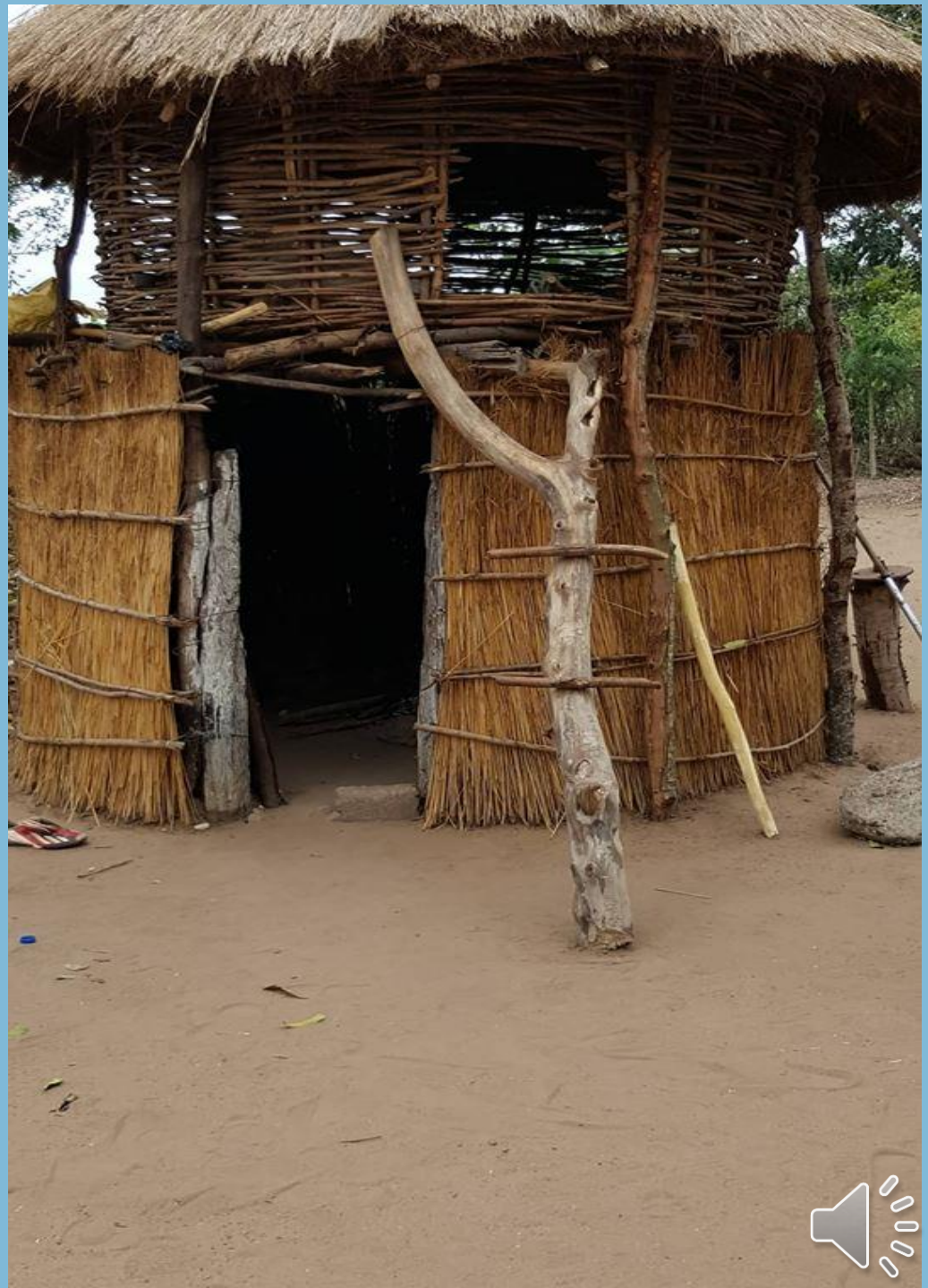
- QUALITATIVE DATA
- QUANTITATIVE DATA



Evaluation

- **Quantitative Data**
  - **Main source: WHO, published material**
  - **System Sensor Measurements & Readings**
- **Qualitative Data**
  - **Main source: Interviews**
- **Summary**

  Six participants
  3 groups representing 3different households
  12 questions
  Interview: face-to-face session



System Test Results

- **Detection range (meters (m))**
- **Sensitivity (PPMs)**

Table 1: Tabulation of Results from laboratory experiments on UD-IAQMWS sensors

TEST CARRIED OUT	SENSOR RESPONSE
ALCOHOL DETECTION	Detectable (not calibrated)
CO_2 DETECTION	Detectable (not calibrated)
SMOKE DETECTION	Detectable (not calibrated)
LPG DETECTION	Detectable (not calibrated)
CO DETECTION	Detectable (calibrated)

NB:
PPMs are determined respectively by cross-referencing sensor data with manufacturer's datasheets and calibrating with a standard sensor.

Interviews

Recurring Patterns

NUMBER	QUESTION	USER RESPONSE
8	Would you like one installed in your home?	All users said, Yes
9	Would you buy the system if it were available for sale?	All users said, Yes
10	What aspects of the system do you like the most? You could give your dislikes as well.	(As a dislike) All users said they worried about the Potential cost
12	What are your general thought about the system and the whole experience?	All users said Positive

Results (1)

Compliance with Universal Design Principles

1. Equitable Use

- Professional
- Nonprofessional
- Impaired Users
- Mobile App delivers 3 types of feedback auditory, tactile and Visual.
- Multiple language

2. Flexibility in Use

- Multiple options functionality
- Customizable
- Intrinsically built to include additional features
- Personalized to meet user's needs.

3. Simple & Intuitive

- Intuitive mobile interface
- No complex gestures
- No special training

Results (2)

Compliance with Universal Design Principles

4. Perceptible Information

- Good display, contrast and colour
- Characters font size 15 to 20-point font.
- Information; images and colour
- provides visual, auditory and tactile feedback... diminishes screen reader support or program

5. Tolerance for Error

- The system indicates error if the sensor fails or get disconnected

Challenges (1)

Research Challenges

- Low Statistical Sample
- Lack of commercial test samples
- Language Barrier
- Lack of participants for Accessibility Evaluation
  (Hence the necessity to use personas)

Challenges (2)

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System Development Challenges

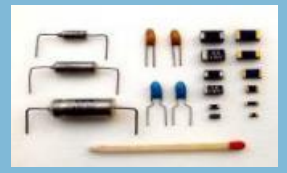
Software:

- Programming more user friendly features leads to increasingly complex lines of code.
- Programming is limited by the compiler employed

Hardware:

- Bulky components = bulky system

- Bulky > Portability
- wearable system = Tiny Components (SMD)



- SMD < $$$

NB: SMDs are difficult handle without specialized tools

Persona

3 Characters are used to demonstrate different situations for users with Impairments.

- Hearing impaired user
- Visually impaired user
- Other system assistive capabilities

Conclusion

The proposed system can detect a wide range of pollutants such as smoke, alcohol, CO, CO2, LPG.

Universally Designed and Accessible

- ❖ Multi-modal IAQ status – audio, visual & tactile
- ❖ Diminishes screen reader support or program

Simple and easy to use

Customizable

UD-IAQMWS!

shutting down

THANK YOU

Please send your comments and questions to
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