



Remote Data Acquisition System in Low Resource Settings

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Outline

Brief Project Overview

Design Specifications

Design Alternatives

Pugh Analysis

Chosen Solution

Budget

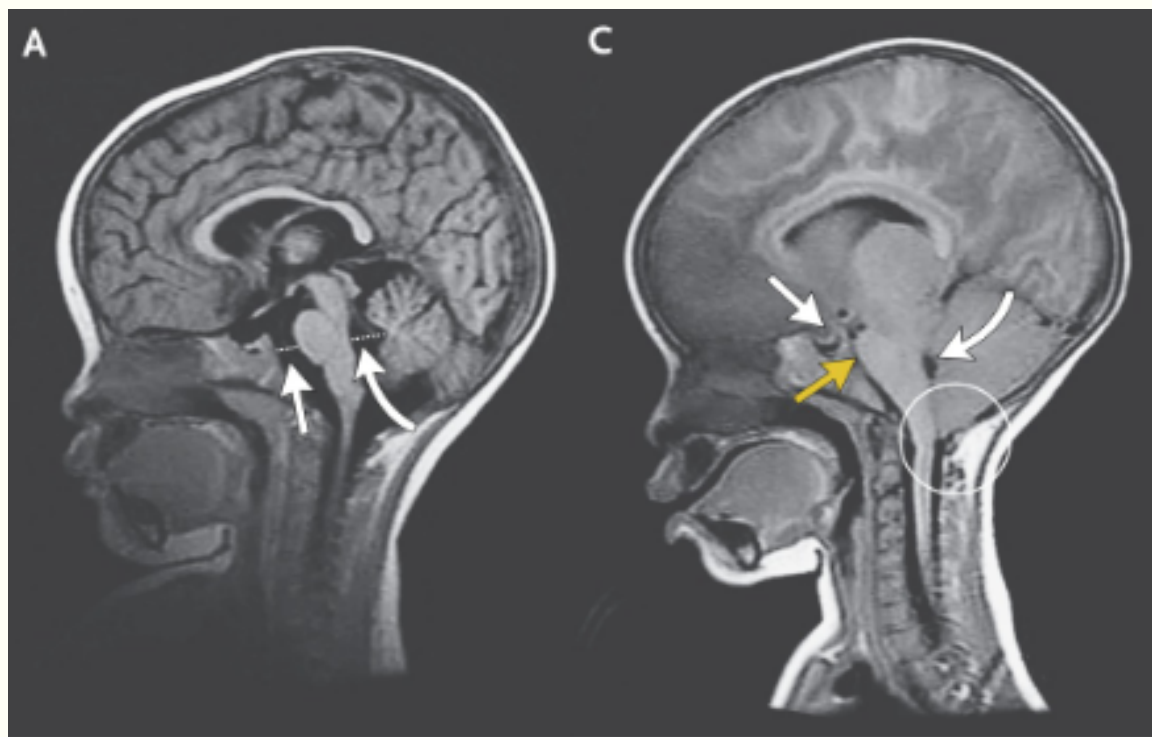
Overview: Why?

Limited access to lab testing and monitoring equipment

Cerebral malaria (CM) causes brain swelling and respiratory arrest

Alternative indices to identify treatable sub-phenotypes

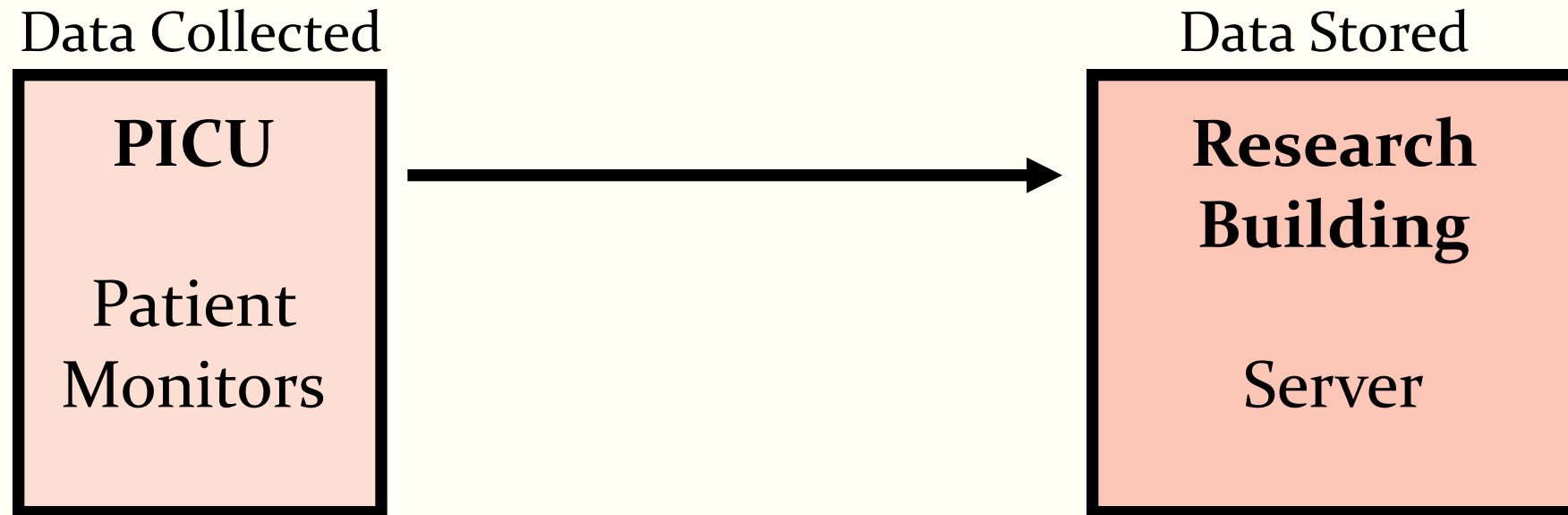
Remote analysis of high resolution ECG & ART waveforms



Seydel et al. (2015)

Overview: Our Major Obstacle

Goal: Archive data from patient monitors, Remotely access server



Obstacles: Thick walls, Distance, Separate networks

Specifications

No changes to design specifications

Data Acquisition	Specification	Metric	
	Cost	<\$500 per unit	
	Measurement	Waveform: ECG (4 lead), Invasive Arterial Blood Pressure (ART)	
		Discrete: Non-Invasive Blood Pressure, Pulse Oximetry	
	Frequency	min: 100 Hz	ideal: 200 Hz
	Sampling Amplitude	16-bit	
	Resolution Range	ECG: 0.5 - 5 V	BP: 0.0V +/- 0.025 V
	Transmission	Wireless. Real-time. Digital output to server.	
Between buildings. Across brick & steel walls. 200 - 300 yards.			
Server	Specification	Metric	
	Software	Receives and archives data in real-time from multiple monitors	
	Accessibility	Remotely view and download real time data archived data	

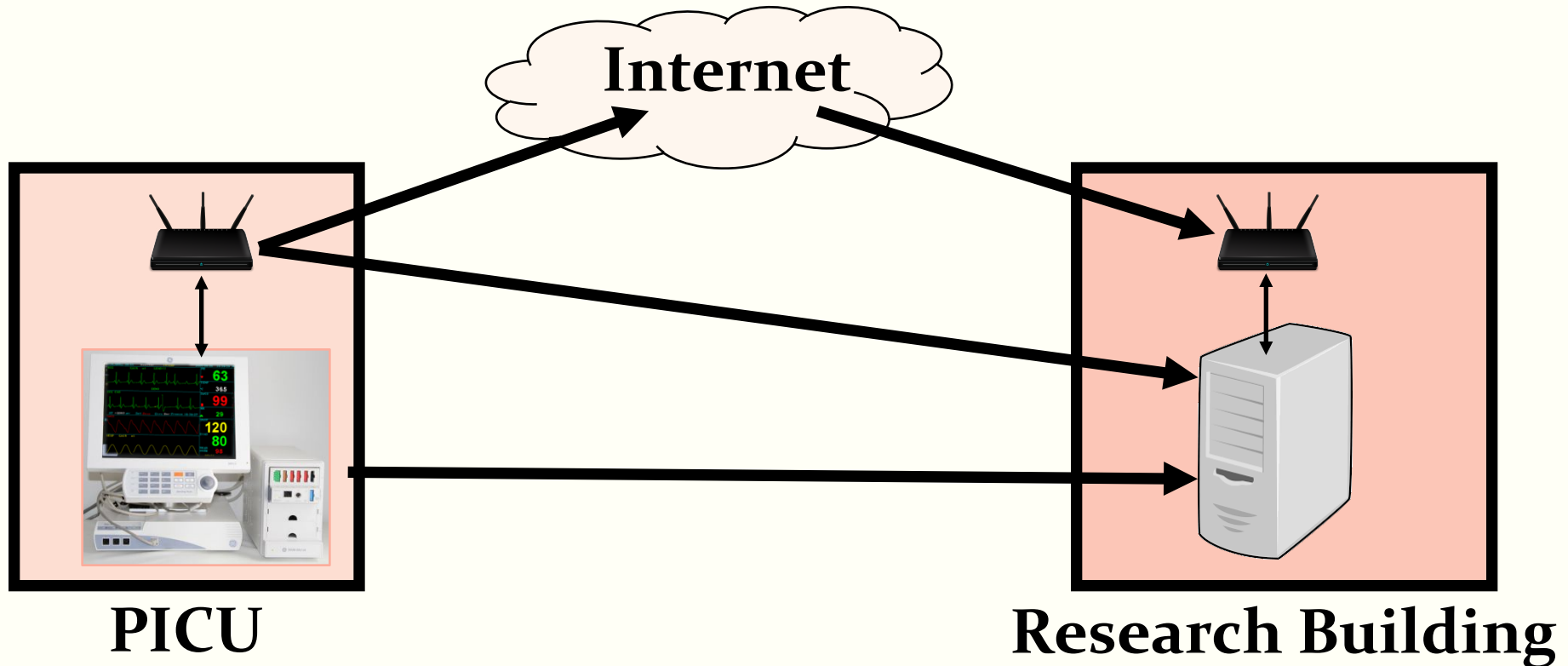
Design Alternatives: Two Approaches

1. Server in Research Building
Transmission-based Solution
2. Server Not in Research Building
Server-based Solution

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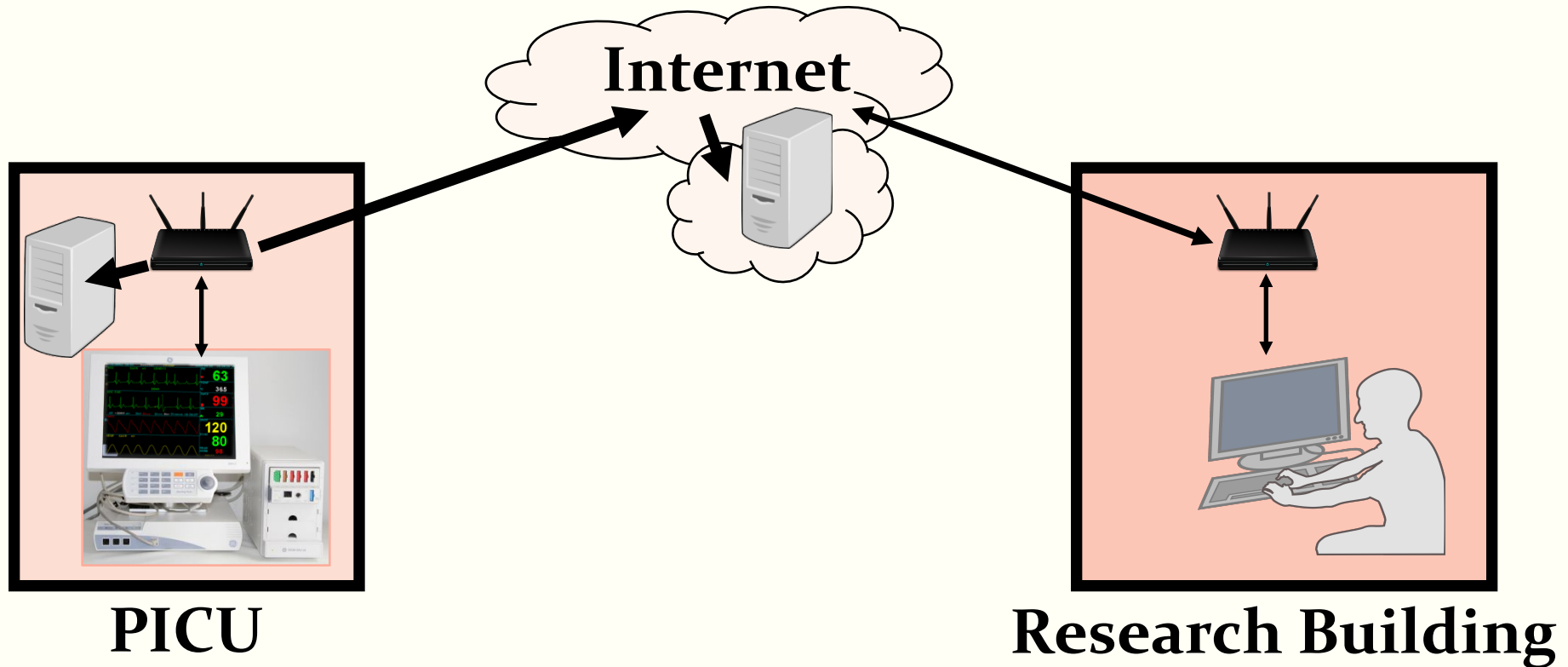
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Design Alternatives: Two Approaches

1. Server in Research Building
Transmission-based Solution

Ethernet with LAN

Infrared

Bluetooth

Zigbee

Ultra-Wideband

Wi-Fi with Directional Antenna

Wi-Fi with VPN Tunnel

Ultra High Frequency Radio

2. Server Not in Research Building
Server-based Solution

Wi-Fi to Cloud Server

Wi-Fi to Remote Access VPN Drive

Transmission: Ethernet with LAN

Wired cable connecting network devices on one local area network (LAN)

PRO

Faster than wireless

Reliable

High bandwidth

High security

CON

Requires new hardwiring

Distance limit, 100-250 m

Transmission: Infrared (IR)

Infrared waves

PRO

Inexpensive

Faster than radio waves

Low energy

CON

Easily obstructed

Cannot pass through walls

Interference from sun

Very short distance, <10 m

Transmission: Bluetooth

Low power radio waves capable of forming personal area network

PRO

Low energy

Trusted devices

Mini network, multiple devices

CON

Physical obstruction

Short distance, max 10-100 m

Transmission: Zigbee

Low data rate, mesh network using radio waves

PRO

Inexpensive

Low power

Reliable

Mesh network, max 64k nodes

CON

Short distance, max 10-100 m

Low bandwidth

Slow

Transmission: Ultra Wideband (UWB)

Short signal pulses of radio waves over wide frequency band

PRO

Very high bandwidth

Inexpensive

Low power

CON

Very short distance, max 10-30 m

Transmission: Wi-Fi with Directional Antenna

Wi-Fi (radio waves) with expanded range via antenna

PRO

Long distance, 300 m - 15 km

High data rate

Interference can be minimized

CON

Some delay

More power

PICU network less stable

Transmission: Wi-Fi with VPN Tunnel

Encrypted data to remote site via public internet

PRO

No distance limit

High security

Easy to install with VPN routers

CON

Additional costs - needs static IP

Depends on network stability

Transmission: Ultra High Frequency (UHF)

High frequency radio waves using an antenna

PRO

More distance than Bluetooth/Wi-Fi

CON

Easily obstructed

Slightly more expensive

Transmission: Wi-Fi with Cloud Server

Storage on web-based server

PRO

No distance limit

No need to connect buildings

Easy to install

Easy to resize

CON

PICU network less stable

ISP limited speed

Monthly cost

Transmission: Wi-Fi with Remote VPN Drive

Private network drive that is remotely accessible by VPN

PRO

No distance limit

No need to connect buildings

Easy to install

Little interference

CON

PICU network less stable

ISP limited speed

Pugh Chart

Design Specifications

<\$500/unit, high resolution data, wireless to 300 m and thick walls, archive data, remote access to server

Pugh Criteria

Logistics: ease of installation, cost

Transmission: wireless, range, interference, delay

Data: bandwidth

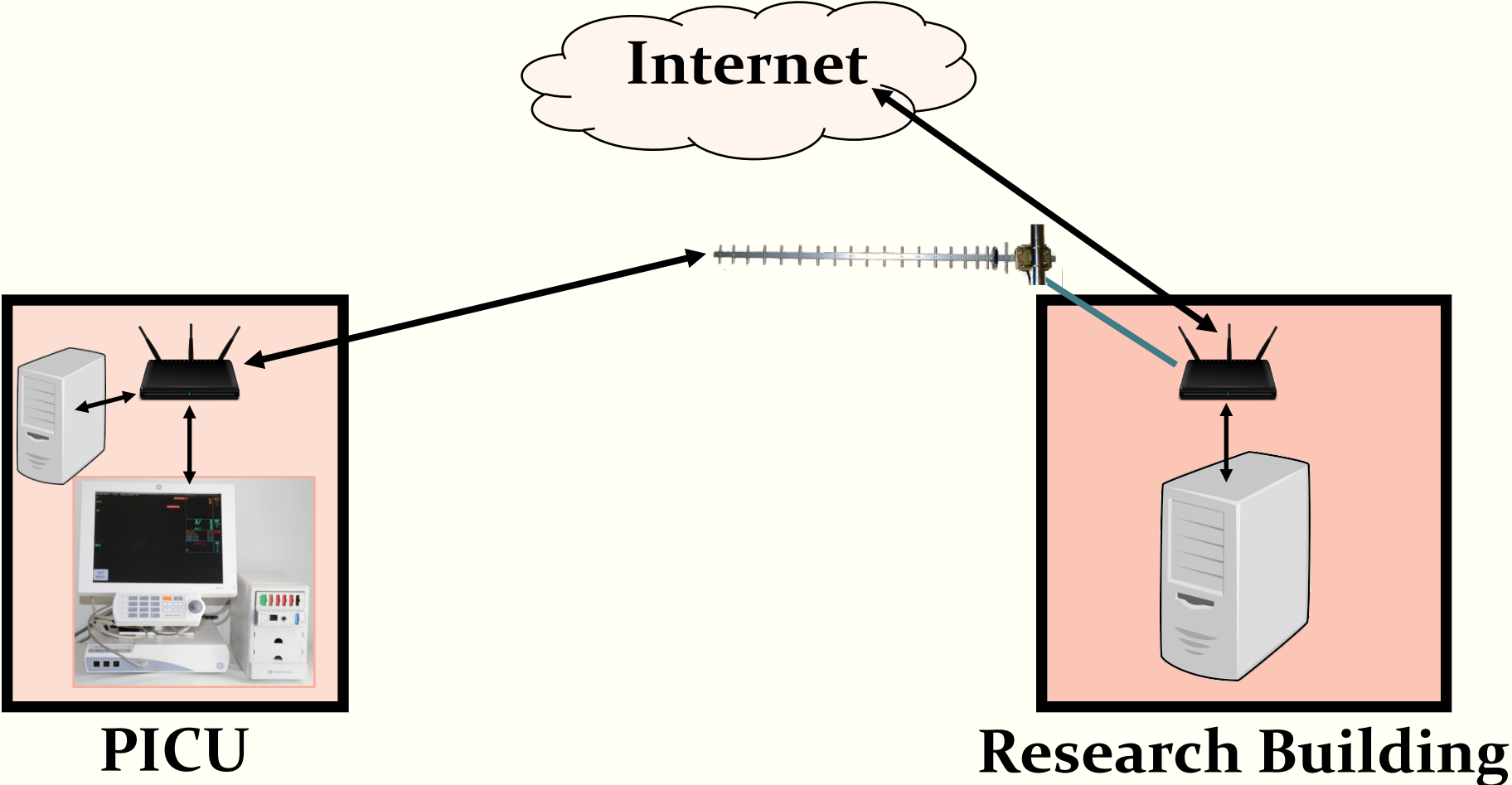
Outline – Overview – Specifications – Alternatives – Pugh – Solution – Budget

Pugh Chart		Weight	Transmission-based								Server-based	
			Ethernet	Infrared	Bluetooth	ZigBee	Ultra-Wideband	Wi-Fi, Directional Antenna	Wi-Fi, VPN Tunnel	Ultra High Frequency	Cloud	Remote Access VPN
Category	Criteria											
Logistics	Ease of Installation	1	1	1	4	3	2	2	4	2	5	5
	Cost	3	3	2	5	5	5	5	4	2	3	4
Transmission	Wireless	5	0	5	5	5	5	5	5	5	5	5
	Range	5	0	1	2	2	1	5	5	5	5	5
	Interference	4	3	2	2	2	2	5	4	3	4	4
	Delay	2	4	4	3	1	4	4	3	2	3	4
Data	Bandwidth	4	5	2	4	2	4	5	3	2	3	5
Weighted Total			50	61	84	71	79	115	100	82	98	111

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Wi-Fi with Directional Antenna



Proposed Budget

	Item	Cost (\$)	Vendor
Wi-Fi with Directional Antenna	Directional Antenna (1)	25	Tupavco on Amazon
	Coaxial Cable, 50 ft (1)	15	KabelDirekt on Amazon
	Server (2)	Provided as needed	TBD

	Item	Cost (\$)	Vendor
Data Acquisition Unit	Arduino Uno WiFi R2	45	Arduino
	Arduino Power Adapter	5	ZJchao on Amazon
	16-bit External ADC	15	Adafruit
	microSD Shield	15	Sparkfun
	microSD, 16 GB	20	Sparkfun

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