



One day Seminar at

The Institution of Engineers (India)
U.P. State Centre, Lucknow



A Technical Talk on

VLSI for Connected Healthcare: From Sensors to Cloud over 5G and Toward 6G

Delivered by-

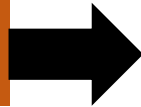
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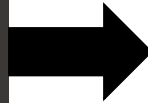
Connected Healthcare Begins with Familiar Devices

Digital thermometer



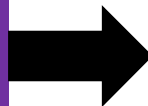
A physical quantity becomes a reading

Finger pulse oximeter



Light helps estimate blood oxygen saturation

Smartwatch



Sensing and processing fit on the wrist

Health changes between hospital visits. Connected devices can help care teams review measurements while a patient is at home.

VLSI for Connected Healthcare: From Sensors to Cloud over 5G and Towards 6G

VLSI Hardware

Tiny electronic chips that process signals, perform calculations and control devices.

Healthcare Sensors

Devices that measure signals such as heart activity, temperature and blood oxygen levels.

5G Connectivity

A mobile network that helps carry health data between devices and healthcare services

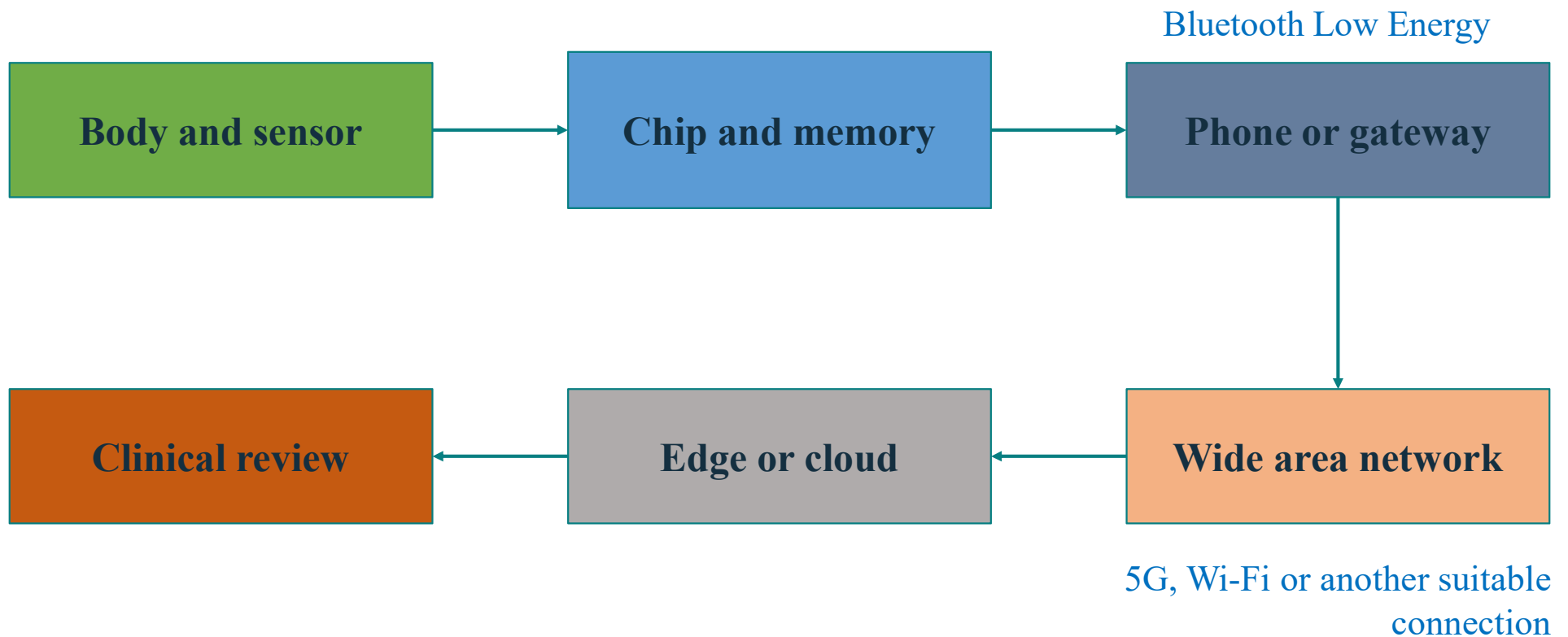
6G

A future generation of connectivity, with potential healthcare applications still being explored.

Cloud

Remote computers that store and analyse data and make it available to authorised care teams.

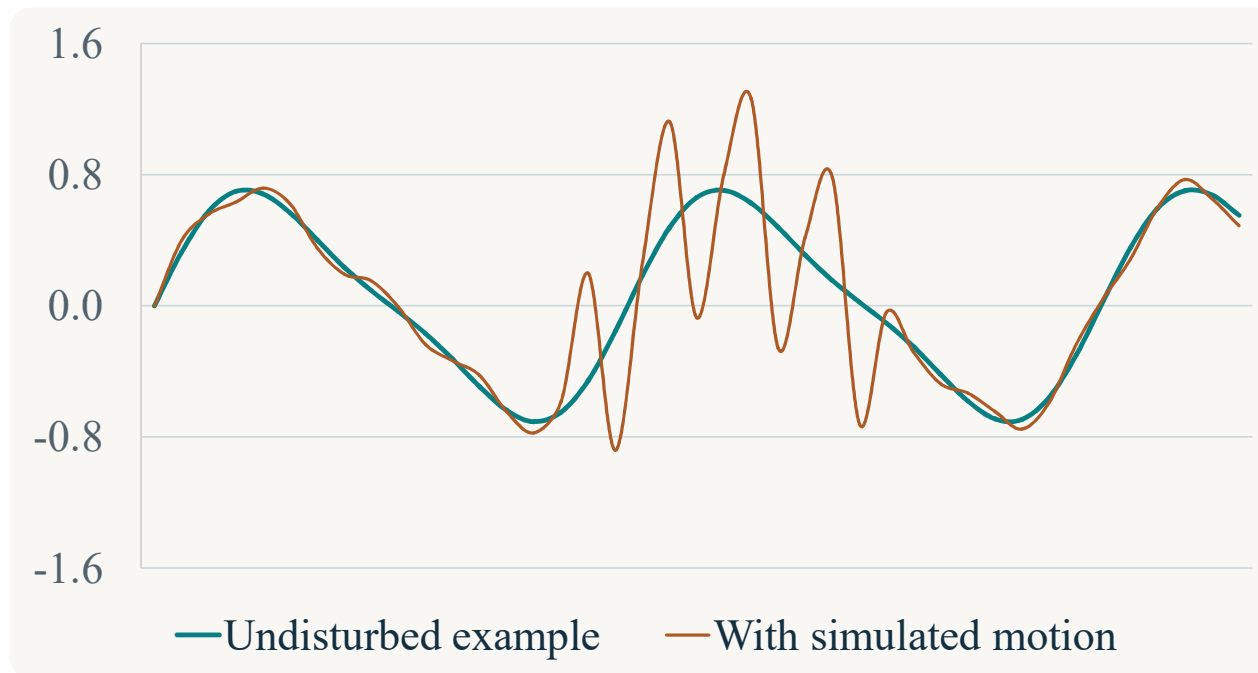
From Your Body to the Care Team: The Journey of Health Data



Listening to the Body: What Sensors Measure

Sensor or method	What it observes	Relatable example
ECG electrodes	Electrical heart activity	Chest patch
Optical sensing	Changes in detected light	Wrist pulse sensor
Temperature sensor	Temperature at the sensor	Digital thermometer
Accelerometer	Acceleration and movement	Activity or motion tracking

A Clear Signal Comes Before Reliable Health Data



**Motion can disturb a
useful signal**

**Like a microphone
in a noisy room**

an ECG patch measures small electrical signals associated with heart activity. If the person moves or an electrode becomes loose, the recorded signal can be distorted.

VLSI: The Tiny Chip Behind Connected Care

Very Large-Scale Integration (VLSI) allows a very large number of transistors to be integrated onto a single semiconductor chip. Which helps in-

Processing: Performing calculations and controlling device operations.

Memory: Storing instructions and measurement data.

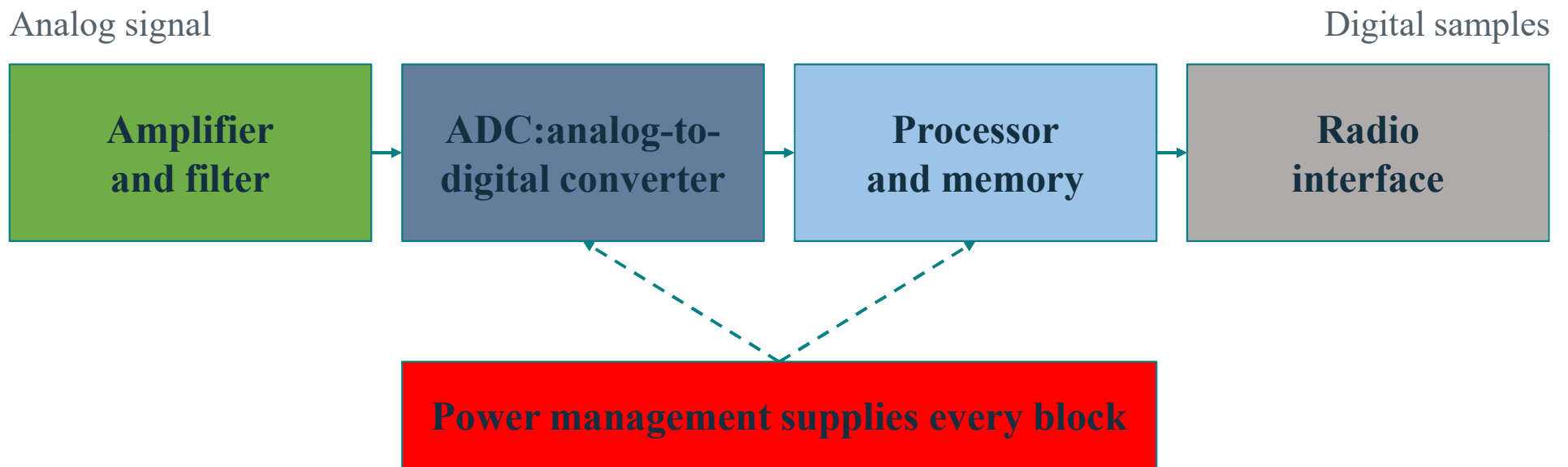
Signal handling: Amplifying, filtering or digitising sensor signals.

Communication: Preparing and exchanging data with other devices.

In a wearable heart monitor, integrated circuits help convert weak electrical signals from the body into digital measurements.

Why it matters: Integration can make healthcare devices smaller and more energy-efficient

The Electronic Building Blocks of a Health Monitor

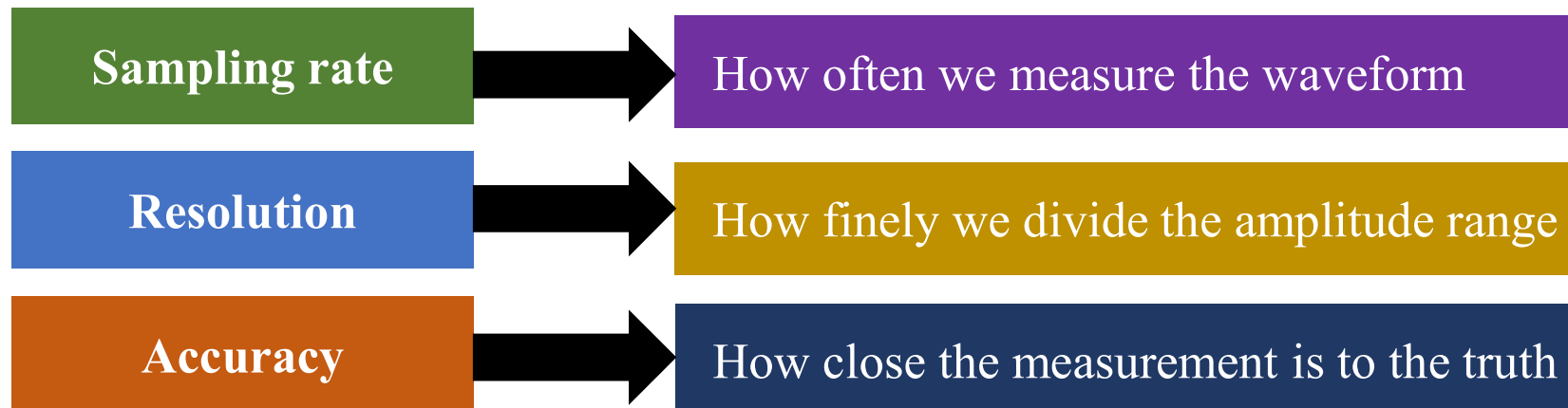


From Body Signals to Numbers a Computer Can Use

ADC = Analog-to-Digital Converter

A sensor produces a continuously varying electrical signal. An ADC measures it at regular intervals and represents each measurement as a digital number.

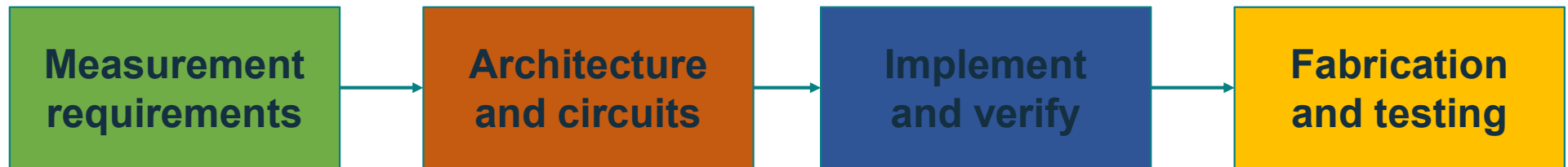
An ECG waveform becomes a sequence of digital samples that can be stored, processed and transmitted.



Hardware choice follows the application

Option	Useful when	Main tradeoff
Microcontroller	Software flexibility matters	Finite processing capacity
FPGA [Field Programmable Gate Array]	Parallel or changing logic helps	Assess power, size and cost
ASIC [Application Specific Integrated Circuit]	A stable function needs optimisation	Development cost and limited hardware changes

The VLSI design process starts with a Patient's requirement



Design Step	The Question Engineers Ask
Define requirements	What must we measure, how accurately, and for how long?
Choose the architecture	Which sensing, processing, memory and communication blocks do we need?
Design and verify	Do the circuits meet function, timing and power requirements?
Fabricate and test	Does the manufactured chip perform as intended?

From the Wearable to the Care Team: The Phone as a Bridge



We have understood the wearable. Now let us get its data off the body.

Coverage, energy, mobility and cost determine the best route.

A heart-monitoring patch sends readings to a phone app, which uploads them for authorized review.

Different Healthcare Tasks, Different Network Needs

The phone has received the measurement. What kind of connection does it need to send it onward?

Think of sending a **text message versus making a video call** - both use a network, but their demands differ.

Healthcare example	What we send	What the connection needs
Temperature monitoring	Occasional readings	Coverage and reliable delivery
Continuous ECG monitoring	A stream of measurements	Reliable delivery with suitable timing
Video consultation	Live sound and images	More bandwidth and stable connectivity

**A simple ECG example: One channel $\times$ 250 samples/second $\times$ 16 bits/sample
= 4,000 bits/second or 4 kilobits/second**

Beyond Speed: What 5G Can Bring to Healthcare

5G service direction	Plain meaning	Healthcare example
Enhanced mobile broadband	Capacity for richer data	Video or imaging consultation
Massive machine-type communication	Many connected devices	Distributed sensors and monitoring
Ultra-reliable low-latency communication	Demanding reliability and delay	Selected interactive applications

The deployed network and the whole application determine actual performance.

Sharing the Work: Device, Edge and Cloud

Location	Example work	Design consideration
Device	Acquire data and check contact	Limited energy and memory
Nearby edge or gateway	computing near the patient or data source. Buffer data and display status	Can reduce reliance on a distant server
Cloud or remote server	Retain records and analyse trends	Needs connectivity and controlled access

During a connection loss: record locally where feasible, show status, upload later.

What changes when the patient is moving?

Care on the Move: Connecting an Ambulance to the Hospital

The challenge: Share useful patient information while the ambulance travels through changing network coverage.

What can be shared?	What must the system handle?
Vital signs and ECG recordings	Reliable measurement despite movement
Voice or video communication	Variable bandwidth and delay
Updates for the receiving hospital	Connection interruptions as coverage changes

Why it matters: Information received before arrival can help the hospital prepare for assessment and treatment.

Role of 5G: Where suitable coverage and capabilities are available, 5G can support mobile data and video communication.

Dependable mobile healthcare needs good sensors, robust hardware and a plan for connection loss-not just a fast network.

Who receives the information and who acts?

Imagine a heart-monitoring patch sends an alert at midnight. Who is expected to review it? What happens if they do not respond? These questions must be answered when designing the service.

Step	What the system needs
Check the measurement	Identify poor signal quality, missing data or connection loss.
Deliver the information	Make readings and alerts available to authorised users.
Assign responsibility	Define who reviews the information and when.
Plan the response	Establish what happens when a reading needs attention or an alert is missed.

Protect the information: Control access, encrypt data and support secure software updates.

An alert on an unattended dashboard has not completed the care pathway.

6G: From Research Trials to Future Healthcare

Where are we today? - October 2026

6G-related prototypes and field trials exist. Standards development is underway, with the ITU framework envisaging deployment from around 2030 onwards. **A research demonstration is different from a standardized commercial 6G service.**

Direction	What it could mean for healthcare
Integrated sensing and communication	Explore contactless observation of movement or breathing using radio signals.
AI and communication	Develop networks that adapt more intelligently to changing conditions.
Broader connectivity	Work towards extending access to remote and underserved communities.

VLSI connection: These ambitions need efficient radio circuits and processing hardware that fit practical power and cost budgets. *This is the engineering implication.*

From Sensors to Care: VLSI Makes the Connection

VLSI provides the compact, energy-efficient hardware that helps turn body signals into useful health information.

Sensors capture what is happening in the body.

VLSI circuits condition, digitise and process those signals within a limited power budget

Gateways and networks—including 5G—carry the data to healthcare services

Edge and cloud systems organise and analyse the information

Care teams review and act through a defined response pathway

Looking ahead: 6G research explores new possibilities; dependable hardware and evidence of clinical usefulness remain essential.

Thank You!!