Telehealth System: Paradigm Shift to Home Healthcare Monitoring

Key Features/ Benefits:

- Interface to multiple human-vitals-monitoring sensors
- Supports off-the-shelf or custom sensor modules
- Cyber security and data privacy
- Flexibility of patient care
- Anytime and anywhere patient consultation

Telehealth systems are providing solutions to the unmet needs of remote patient consultation, remote patient diagnosis, and remote patient prescription by utilizing the latest wireless communication technologies. They use proven, off-the-shelf wireless communication protocols to establish communication between home-based patients and remote physicians or caregivers. This gives flexibility to connect with your physician anytime and anywhere. Additionally, multiple human-vitals-monitoring sensors can be interfaced with this system, including SpO2, HR, temperature, HbA1c, ECG (multiple lead option), otoscope, NIBP, and spirometer. This interface can be extended to other sensors as well with minor customization to the system due to the modular nature of the design.

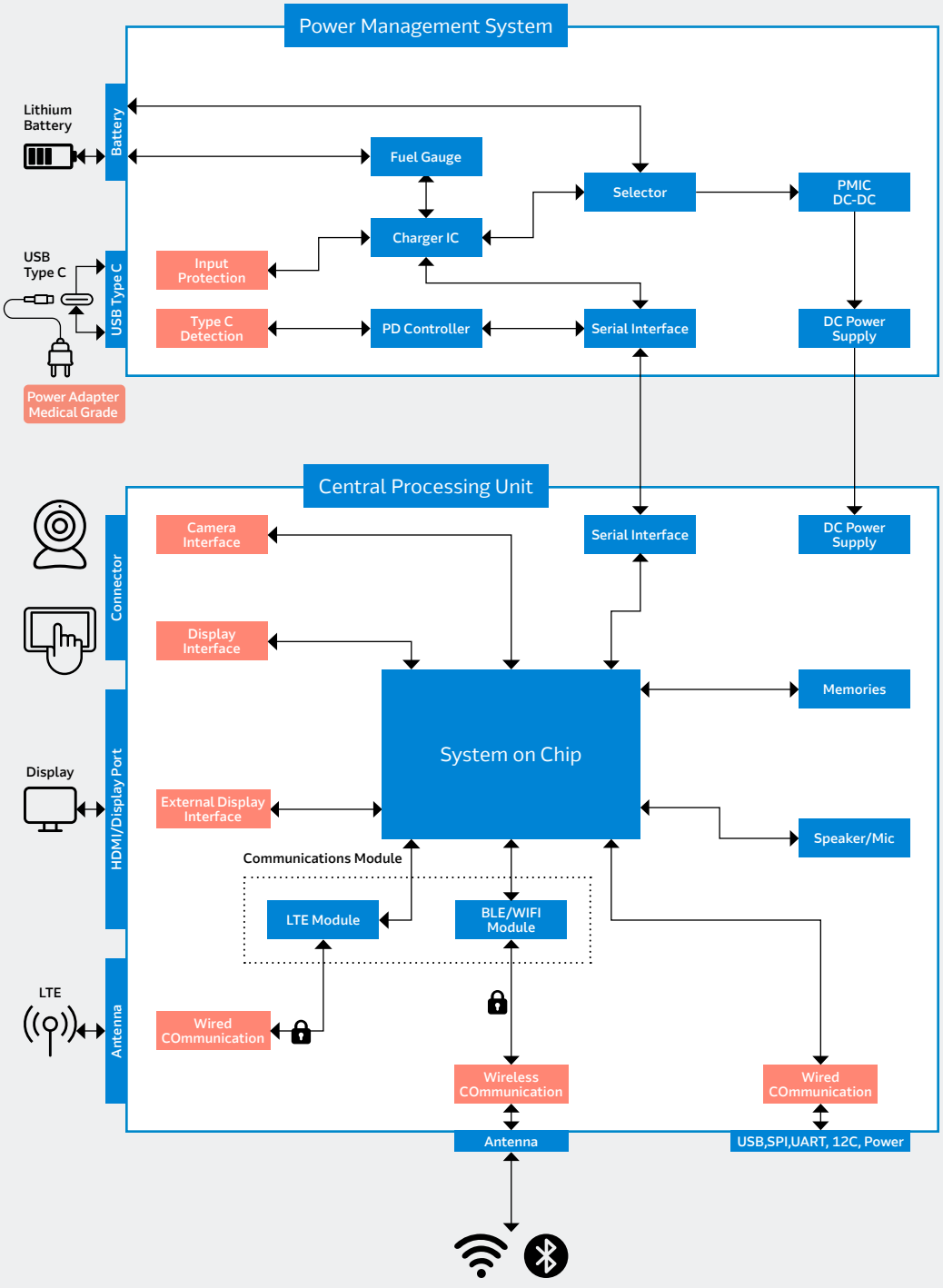
This system could enable a secure interface for transfer of all patient data and vitals parameters over the Internet or Wi-Fi to remote physicians or caregivers. Additionally, there is live video/audio streaming capability that enables communication between a patient and their remote physician. These designs include an integrated camera and speaker system to enable high-quality streaming.

The portable telehealth device could be used in hospitals, mobile clinics, rural clinics, health provider locations, and during home visits. These portable telehealth devices achieve mobile screening and offer convenience for patients to have health checks and online doctor visits. This will dramatically widen the areas of primary health care and build up the chronic-disease-monitoring network across the country. The following improvements can be realized.

- The public could have convenient health checkups at any time and almost anywhere.
- Expedited test result communication.
- All the records can be digitalized and archived in electronic medical records.
- All the health data can be stored as a lifetime record, so each person could have a lifetime health-tracking archive.
- The doctors can more easily diagnose based on the health-checkup results.
- Efficient use of time for both patients and doctors, eliminating transportation costs and waiting room queues.

System Block Diagram

The telehealth system requires a device that connects a remote patient to a doctor. This device involves an audio-video communication interface and connectivity via wired or wireless technologies. The device involves many different electrical and mechanical components to work together efficiently with minimal feedback delays — i.e., several pieces of hardware including a power management unit, a central processing unit, communication interface, and sensor interface. The central processing unit is the main element of the system that interfaces with all other components. There is device firmware, application software, and a cloud connectivity interface for communication.



System Benefits

Systems-on-a-Chip (SoCs) are available with options having single- to multi-core processors in a common footprint. The SoC would consist of 2D/3D GPU, VPU, video and audio decode and encode engines, neural processing engines, a security module, and peripheral interfaces. The SoC runs different operating systems which may require RAM and storage memory controllers to connect with external RAM and eMMC/UFS/flash-based memory with different capacity requirements. The SoC would be selected based on the end-user requirement to configure the telehealth system.

A main advantage of the SoC is the capability to run AI models directly on the MCU so that edge devices can make intelligent decisions without the need to send data to the cloud or to a remote server for processing. This can greatly reduce latency and improve response time, which is critical for real-time applications such as sensor-testing devices. Additionally, running AI models on the MCU or MPU can significantly reduce power consumption and cost compared to using a separate processor for AI — making it a more practical solution for many applications. Lastly, the cryptographic acceleration modules, secure boot, secure non-volatile storage, and secure RAM options are supported by SoC features.

The use of a **display interface** on SoCs can make it easier for patients and healthcare providers to understand sensor-device readings. A display can provide real-time feedback during measurement and offer additional features like touch input and graphical user interface. The camera modules can be interfaced with MIPI-CSI to the SoC. Embedded displays are available in varied sizes/resolutions and interfaces like MIPI-DSI or LVDS to connect with the SoC. The SoC also supports external display interfaces such as HDMI or display port. The audio codec interface on the SoC can provide multiple analog or digital microphone interfaces and speaker amplifiers to connect in the device. Either an external 3.5mm audio jack or Bluetooth-based audio connectivity can be supported by the audio engine and operating system running on the device.

The wireless **communication module** includes Wi-Fi, Bluetooth, and LTE/5G — commonly used interfaces in the market. There are external wireless modules or chipset-based solutions with the latest technology standards available. These modules or chipsets can be interfaced with the SoC over USB, PCIe, UART, PCM, and SDIO interfaces. Using LTE and Bluetooth Low Energy (BLE) as wireless communication protocols offers several benefits. LTE and BLE provide a secure and reliable wireless connection to transmit test-sensor data in real time, allowing healthcare providers to monitor patients remotely and respond quickly in case of any abnormalities. LTE is used for global communication and data transfer between the patient and doctor. BLE is used for transmitting data from a sensor-test device to a control device in real time. Overall, using LTE and BLE as wireless communication protocols on a sensor-testing device can improve patient care, enhance the patient experience, and increase the efficiency of healthcare providers.

Power management is critical for the successful operation of edge solutions, particularly for battery-operated devices. First, USB-C is a versatile interface that can provide both power and data communication, allowing a single cable to provide both functions. This simplifies the design of the edge solution and reduces the number of cables required. Second, including a battery in the edge solution provides backup power in case of a power outage and allows the device to operate independently of a power outlet. Additionally, a battery can smooth out power fluctuations and reduce the strain on the PMIC, improving overall system stability. Third, a fuel gauge can be used to accurately measure the battery's state of charge and remaining power. This helps prevent unexpected power loss and allows for better power management. Finally, a PMIC can be used to efficiently convert the battery voltage to multiple output voltages required by the system. This reduces power loss and improves energy efficiency, thus extending the device's battery life. Overall, implementing power management using USB-C, a battery, and a PMIC can improve the reliability and efficiency of edge solutions while providing a more flexible and convenient user experience.

This system is portable, mobile, and has plug-in capabilities for monitoring devices for

human vitals parameters. These plug-ins can be done through USB, SPI, UART, I2C, BLE, or Wi-Fi. Depending upon the use case, patients can use these monitoring devices (SpO2, spirometer, ECG, BGM, IR temperature, and otoscope) for their home healthcare. This approach provides the healthcare professional with all the parametric data to enhance a patient's care and well-being remotely in a secure environment.

Training/Resources

SYSTEM ON CHIP (SOC)
NXP
Arrow Link | Data Sheet

Qualcomm
Arrow Link | Data Sheet

NVIDIA
Arrow Link | Data Sheet

Intel based
Arrow Link | Data Sheet
Arrow Link | Data Sheet

POWER – BATTERY CHARGER IC
Analog Devices
Arrow Link | Data Sheet

Microchip
Arrow Link | Data Sheet

Onsemi
Arrow Link | Data Sheet

Maxim Integrated
Arrow Link | Data Sheet

BLE MODULE
Microchip
Arrow Link | Data Sheet

Silicon Labs
Arrow Link | Data Sheet

ST
Arrow Link | Data Sheet

Murata
Arrow Link | Data Sheet

Fanstel
Arrow Link | Data Sheet

WIFI MODULE
Silicon Labs
Arrow Link | Data Sheet

Microchip
Arrow Link | Data Sheet

Qualcomm
Arrow Link

BLE + WIFI MODULE
Silicon Labs
Arrow Link | Data Sheet

Murata
Arrow Link | Data Sheet

Quectel
Arrow Link | Data Sheet

LTE MODULE
Quectel
Arrow Link | Data Sheet

Telite
Arrow Link | Data Sheet

PMIC
Analog Devices
Arrow Link | Data Sheet
Arrow Link | Data Sheet

Qualcomm
Arrow Link

NXP
Arrow Link | Data Sheet

Onsemi
Arrow Link | Data Sheet

Infineon
Arrow Link | Data Sheet

Maxim Integrated
Arrow Link | Data Sheet

DISPLAY
Displaytech
Arrow Link | Data Sheet

DFRobot
Arrow Link | Data Sheet

Phoenix Contact
Arrow Link | Data Sheet

Matrix Orbital
Arrow Link | Data Sheet

4D Systems
Arrow Link | Data Sheet

Advantech
Arrow Link | Data Sheet

MEMORY
Micron
Arrow Link | Data Sheet

Infineon
Arrow Link | Data Sheet

Onsemi
Arrow Link | Data Sheet

Microchip
Arrow Link | Data Sheet

CAMERA MODULE
Sony
Arrow Link | Data Sheet

Omnivision
Arrow Link | Data Sheet

Leopard Imaging
Arrow Link | Data Sheet

Lantronix
Arrow Link | Data Sheet

USB TYPE-C CONNECTORS
Molex
Arrow Link | Data Sheet

TE
Arrow Link | Data Sheet

Amphenol
Arrow Link | Data Sheet

CUI Device
Arrow Link | Data Sheet

FFC/FPC CONNECTORS
Molex
Arrow Link | Data Sheet

TE
Arrow Link | Data Sheet

SAMTEC
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Kyocera
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Amphenol
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ANTENNA
TE
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Arrow Link | Data Sheet
Arrow Link | Data Sheet

BATTERY CONNECTORS
Molex
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TE
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Kyocera
Arrow Link | Data Sheet

SPEAKER
PUI Audio, Inc
Arrow Link | Data Sheet

DFRobot
Arrow Link | Data Sheet

CUI Devices
Arrow Link | Data Sheet

FUEL GAUGE
Maxim Integrated
Arrow Link | Data Sheet

ST
Arrow Link | Data Sheet

Qualcomm
Arrow Link