Cimarron Systems

CS365-TI Digital Media Software Development Kit

Features

- Cimarron Systems Digital Media Software Development Kit (DMSDK) for the Texas Instruments TMS320DM365 DaVinci Media Processor running DVSDK 4.02
  - DMSDK A/V RTP Streaming Server Application:
    RTP/RTCP server that encodes/streams H.264 video at 1280 x 720p 30 fps and AAC-LC at 32 ksps.
  - DMSDK A/V RTP Streaming Client Application:
    RTP/RTCP client that receives, reassembles and writes-to-file H.264 video and AAC-LC audio while it simultaneously encodes reassembled video and audio frames into a MPEG-2 Transport Stream.
  - In realtime, encodes reassembled H.264 video and AAC-LC audio into a MPEG-2 Transport Stream.
  - Implements an Automatic Exposure/White Balance Control Loop.
  - Inputs from Component Video Input and LI-5M02 Camera Board.[1]
  - RTP A/V Streaming Client/Server Input/Output via Ethernet.
- Texas Instruments TMS320DM365 DVEVM DVSDK 4.02
  - Arago Community Linux Kernel with build system;
  - Platform Support Package (PSP) including U-Boot bootloader, memory manager, and interrupt controller; and
  - Codec Engine with fully parameterized H.264, MPEG-4, MPEG-2, AAC-LC, G.711, and JPEG codecs.
  - Texas Instruments Digital Media Application Interface (DMAI) video, audio, and speech encode and decode example applications.
  - Texas Instruments Digital Video Test Bench (DVTB) encode and decode codec test/validation applications.
  - Texas Instruments Qt Embedded GUI Interface Builder and example applications.
  - Texas Instruments GStreamer with DaVinci Plugin and example pipelines.

Overview of the Development Environment

The CS365-TI Digital Media Software Development Kit is a set of software components, applications, tools, and documentation designed to equip the experienced engineer with the means for fast, standards-based development of digital media encoding, decoding, and streaming applications for the Texas Instruments TMS320DM365 DaVinci Digital Media Processor (for development with the Texas Instruments TMS320DM368, please refer to the Cimarron Systems CS368-TI DMSDK Datasheet).

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[1] A high-resolution digital camera board, the LI-5M02, is available for purchase from Leopard Imaging at https://www.leopardimaging.com/. The camera board incorporates an Aptina MT9P031 CMOS Digital Image Sensor which has an active imaging pixel array of 2592H x 1944V.

Figure 1 shows a context diagram of the typical environment in which the CS365-TI DMSDK operates including: the TM320DM365 DVEVM hosting the DMSDK, a Ubuntu Linux Host computer hosting the Texas Instruments TMS320DM365 DVSDK 4.02, an audio/video source device, and an audio/video output device.
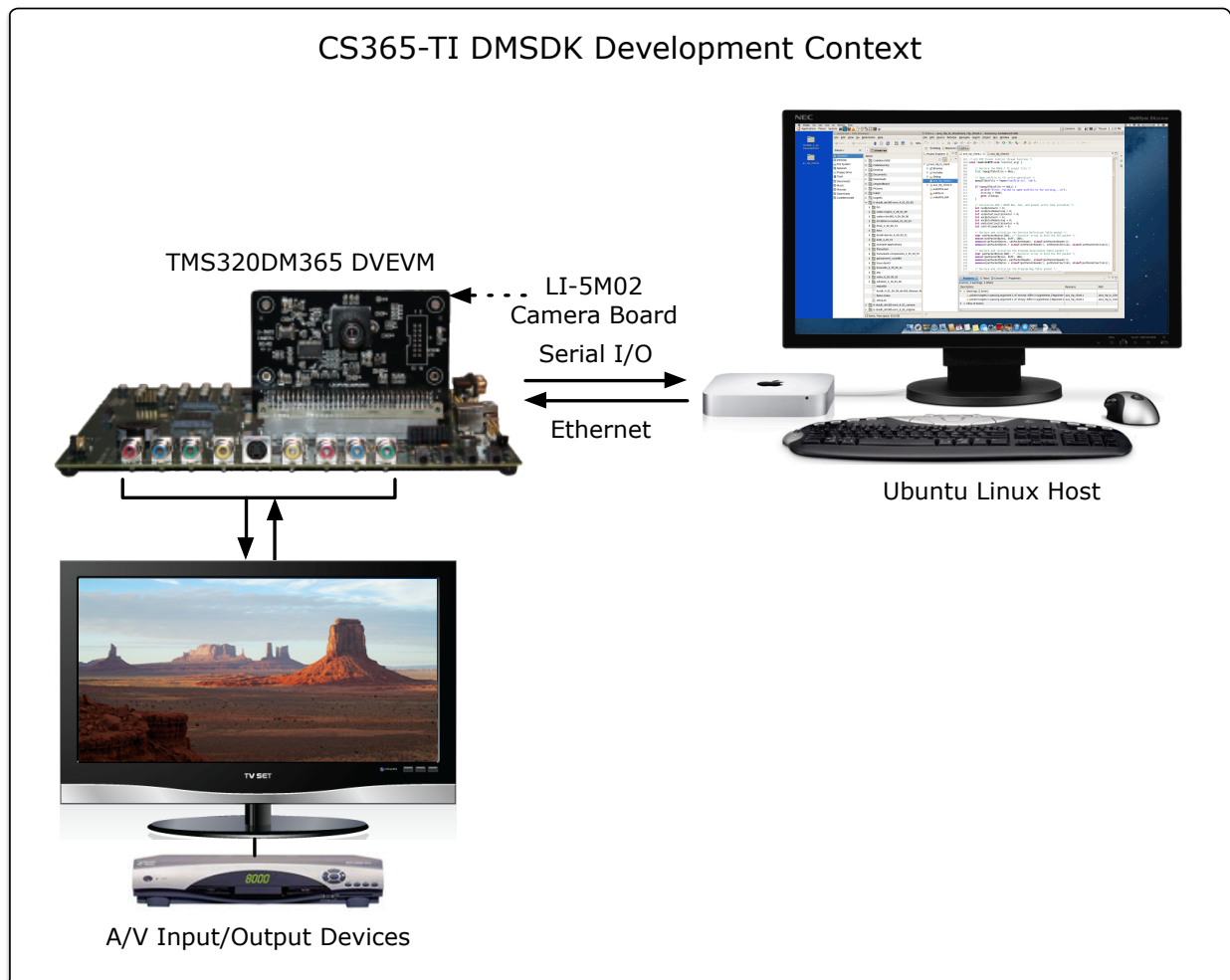

Figure 1: CS365-TI DMSDK Development Context Diagram.

Illustrated in Figure 2, key features of the Texas Instruments TMS320DM365 DVEVM development platform hardware are:

- TI TMS329DM365 ARM9-based processor operating at 300 MHz with 2 Gbytes NAND Flash and 128 Mbytes of DDR2 RAM.
- Component Video Input for video capture/processing at resolutions up to 1280 x 720p at 30 fps.
- Composite Video Input for video capture/processing of NTSC or PAL video formats.
- Component Video Output for video processing/playback at resolutions up to 1280 x 720p at 30 fps.
- Interface for connecting an optional video or still camera with sensor sizes up to 2592H x 1944V pixels.
- Interface for connecting/processing an optional RGB LCD module.
- RS-232 Interface for full-duplex terminal communication to the host at up 115,000 bps.
- Ethernet 10/100Base-T for full-duplex communication to the host at up 100 Mbps.
- USB Interface capable of operating in either host or slave mode.

- Dual SD/MMC/MS/MMC/SD Card Interfaces for up to 8 Gbytes per card storage and/or boot source.
- Audio Interface for processing stereo audio line in/out, microphone in, and stereo headphones out.
- IR receiver interface for processing inputs from a multi-function multimedia remote controller.
- JTAG Interface input connectors for both 14-pin and 20-pin debug cables.
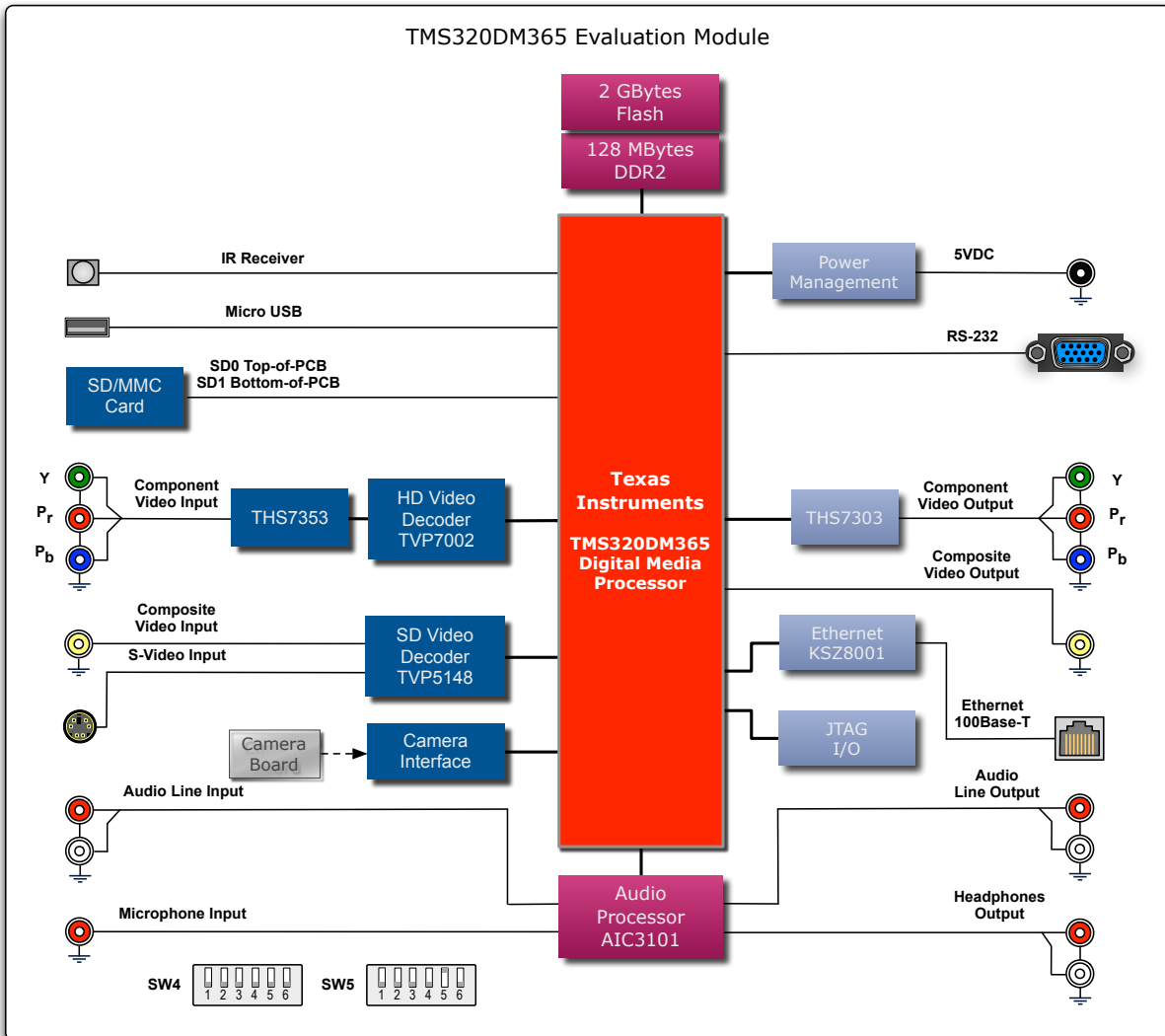- 5VDC power input connector.

Figure 2: Texas Instruments DaVinci TMS320DM365 DVEVM Block Diagram.

As shown in Figure 3, the core software components of the TMS320DM365 DVSDK 4.02 are:

- *DaVinci Multimedia Application Interface (DMAI):* a thin utility layer positioned on top of the Linux OS and the Codec Engine that enables the developer to quickly write portable applications for the DaVinci platform. For details regarding DMAI usage, please see *DaVinci Multimedia Application Interface (DMAI) 2.20.00 Build 15 User Guide*.

- *eXpress DSP Algorithm Interoperability Standard (XDAIS)* includes a version that has been extended for digital media is know as XDAIS-DM or, for simplicity, XDM*:* the XDM standard defines a set of APIs that are uniform across various multimedia codecs designed to ease integration and ensure interoperability. For a description of XDM usage, please refer to the *XDAIS Interface Reference*.
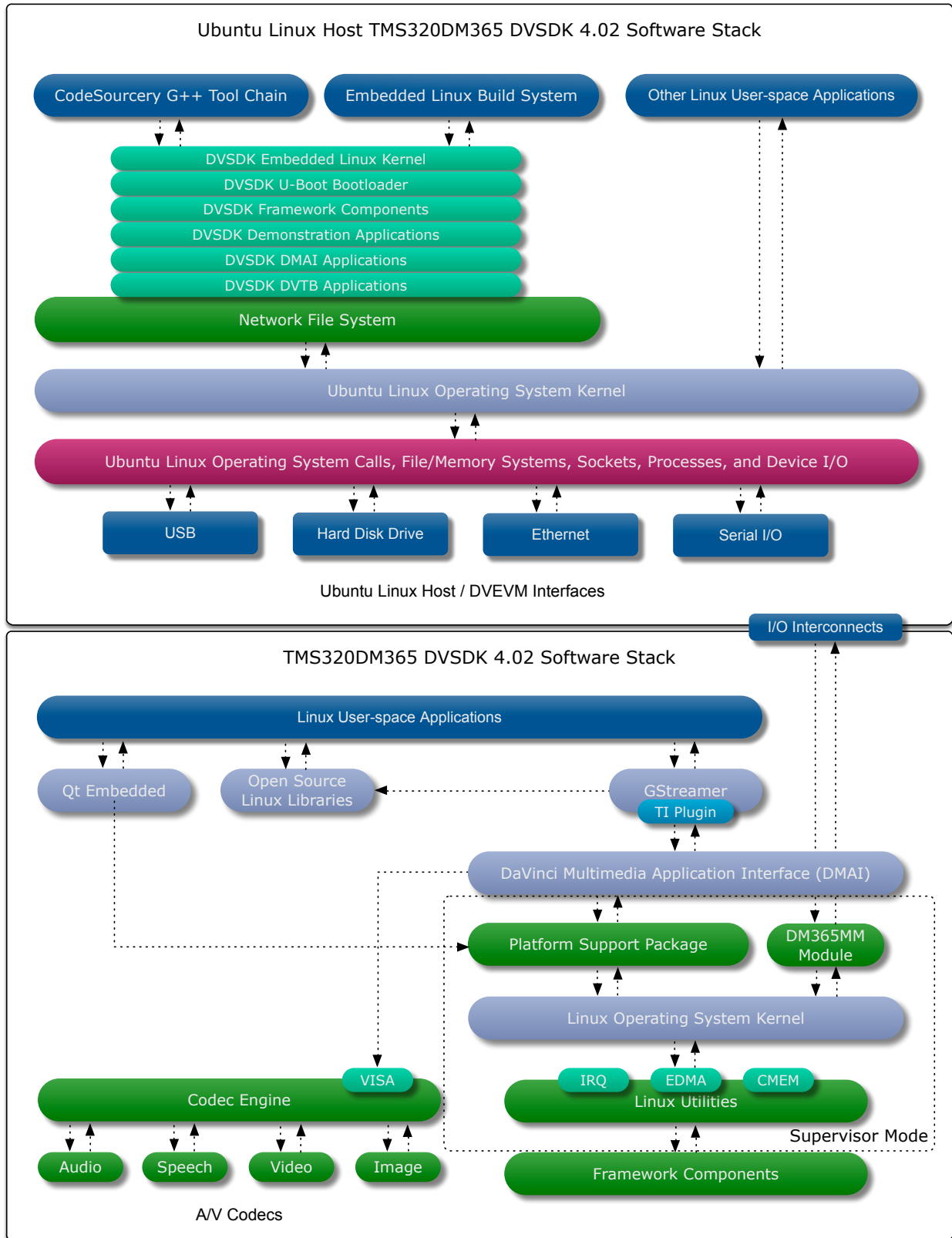
Ubuntu Linux Host TMS320DM365 DVSDK 4.02 Software Stack

CodeSourcery G++ Tool Chain   **Embedded Linux Build System**   **Other Linux User-space Applications**

DVSDK Embedded Linux Kernel
DVSDK U-Boot Bootloader
DVSDK Framework Components
DVSDK Demonstration Applications
DVSDK DMAI Applications
DVSDK DVTB Applications

Network File System

Ubuntu Linux Operating System Kernel

Ubuntu Linux Operating System Calls, File/Memory Systems, Sockets, Processes, and Device I/O

USB   **Hard Disk Drive**   **Ethernet**   **Serial I/O**

Ubuntu Linux Host / DVEVM Interfaces

I/O Interconnects

TMS320DM365 DVSDK 4.02 Software Stack

Linux User-space Applications

Qt Embedded   **Open Source Linux Libraries**   **GStreamer** **TI Plugin**

DaVinci Multimedia Application Interface (DMAI)

Platform Support Package   **DM365MM Module**

Linux Operating System Kernel

VISA   **Codec Engine**   **IRQ** **EDMA** **CMEM** **Linux Utilities**

Supervisor Mode

Audio   **Speech**   **Video**   **Image**   **Framework Components**

A/V Codecs

Figure 3: Ubuntu Linux Host and Texas Instruments TMS320DM365 DVSDK 4.02 Software Architecture.

- *Video, Image, Speech, and Audio (VISA) Classes:* a set of multimedia codec interface classes that

allow applications straightforward methods for utilizing video, audio, speech, and imaging codecs. For details concerning VISA Classes, please refer to the *XDAIS Interface Reference*.

- *Codec Engine (CE):* the Codec Engine framework manages the life cycle of algorithms that comply with the XDAIS-DM standard. For a description of Codec Engine functions, please see the *Codec Engine Algorithm Creator User's Guide*.
- *Platform Support Package (PSP):* the DVEVM DM365 PSP contains the following components:
  - Baseport DM365 SoC support
  - Baseport DVEVM support
  - EDMA support
  - GPIO support
  - Video drivers:
    - Video capture
    - Video display
    - IPIPE previewer/resizer
    - H3A–AF/AEW

  For more details, please see the *DaVinci PSP Linux Installation User Guide*.

- *Framework Components (FC):* Framework Components for the DVEVM DM365 contains a number of software components that are specific to the DM365 hardware architecture. For more detail, please refer to the *Framework Components API Reference*.
- *Linux Utilities (LinuxUtils):* Linux Utilities for the DVEVM DM365 contains the following components:
  - CMEM Manager
  - EDMA Manager
  - SDMA Manager
  - VICP Manager

  For more details, please refer to the *Linux Utils API Reference*.

For additional information concerning set-up of the DVEVM hardware, please refer to the Texas Instruments *TMS320DM365 DVEVM Quick Start Guide*; in order to download the Texas Instruments DVSDK 4.02, follow the links at: http://www.ti.com/tool/linuxdvsdk-dm36x; and for initial installation of the software components, please refer to the Texas Instruments *TMS320DM365 Software Developers Guide*. For installation of the CS365-TI DMSDK, please refer to the Cimarron Systems *CS365-TI DMSDK Installation Guide*.

DMSDK Functional Architecture

As illustrated in Figure 4, the CS365-TI DMSDK software architecture includes functional modules that implement the RTP A/V Streaming Server on the TMS320DM365 DVEVM and the RTP A/V Streaming Client on the Ubuntu Linux Host. The RTP A/V Streaming Server Application includes: an A/V Capture; H.264 Video Encoder; AAC-LC Audio Encoder; RTCP Transmitter User Agent; and RTP Transmitter components. The Streaming A/V Client Application includes: a RTP Receiver; a RTCP Receiver User Agent; MPEG-2 Transport Stream (TS) Encoder that multiplexes the encoded H.264 video and AAC-LC audio into a transport stream; and MPEG-2 TS Output/File Writer components.

The primary functions performed by both the RTP A/V Streaming Server and Client Application components are described in the next sections.
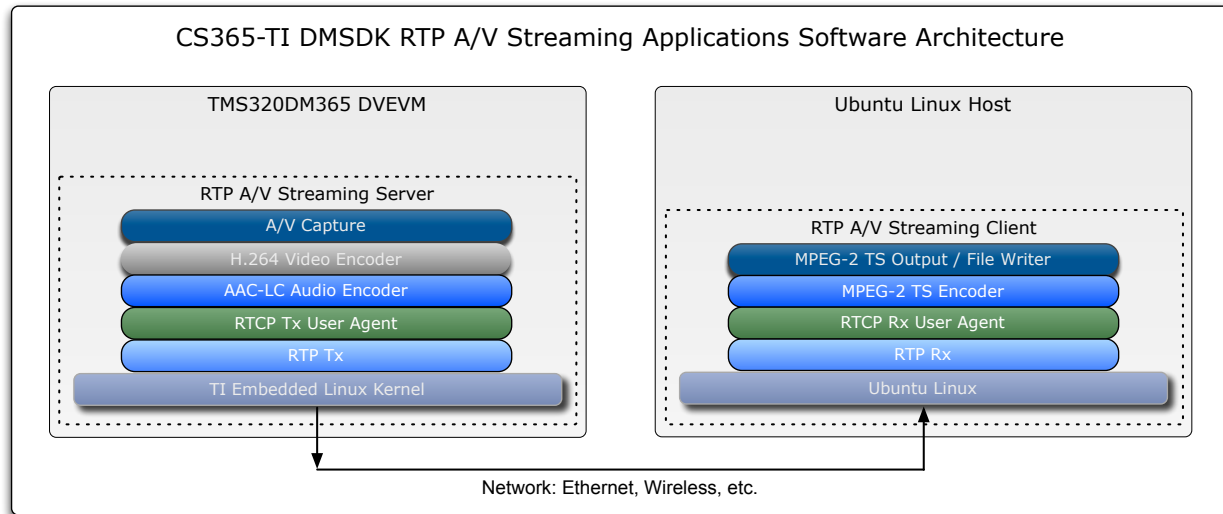
Figure 4: CS365-TI DMSDK RTP A/V Streaming Application Software Architectural Diagram.

RTP A/V Streaming Server Functional Modules

As illustrated in Figure 5, the TMS320DM365 DVEVM RTP A/V Streaming Server application includes modules that implement video and audio capture; buffer input/output, creation, and execution functions for the codecs that encode A/V; the encoded A/V bit stream management function; the encoded A/V bit stream RTP packetization function; the RTCP user agent; the RTP/UDP/IP transmit and receive functions; and the main function.

A short description of each of the TMS320DM365 DVEVM CS365-TI DMSDK RTP A/V Streaming Server functional modules is presented below:

- **User Interface/Control:** provides the user interface as well as start-up, shut-down, and thread control services to the application.
- **Global Time:** provides a global timekeeping service to the application and any of its threads.
- **Capture:**
    - initializes, manages, and deletes the video capture buffer processes.
    - when the Component Video Input is selected, initializes the Video Processing Front End.
    - when the LI-5M02 Camera Board Input is selected, initializes the Image Pipe for input from the camera; programs the Automatic Exposure/White Balance Engine with an expose sampling window and an initial sensor gain value; and dynamically adjusts the sensor gain value based on ambient light conditions.
- **H.264 Video Encoder:**
    - initializes, manages, and shuts down the H.264 video codec.
    - initializes, manages, and deletes the video encoder output buffers.
    - passes H.264 encoded video bitstreams to the Video RTP Transmitter.
- **AAC-LC Audio Encoder:**
    - initializes, manages, and shuts down the AAC-LC audio codec.
    - initializes, manages, and deletes the audio encoder output buffers.
    - passes AAC-LC encoded audio bitstreams to the Audio RTP Transmitter.
- **DV RTP Transmitter/RTCP User Agent:**
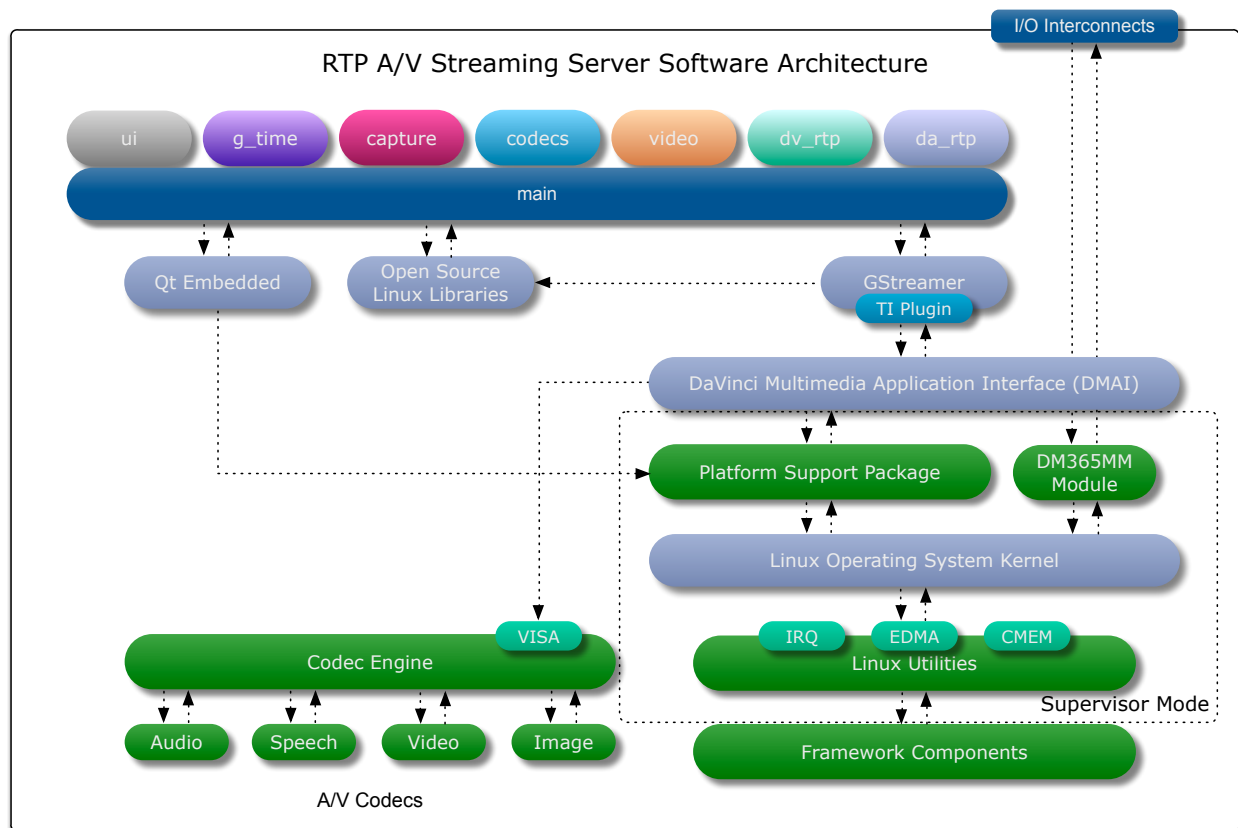   - receives/processes Video RTCP Rx User Agent Client Messages.

Figure 5: RTP A/V Streaming Server Software Architectural Diagram.

- controls the Video RTCP Tx User Agent User Agent.
- initializes, manages, and shuts down the Video RTP Transmitter in accordance with certain system parameters.
- initializes, manages, and shuts down the Video RTP Transmitter sockets in accordance with certain system parameters.
- independently forms the H.264 video bitstream into Video RTP Transmitter packets then transmits them onto the network and, optionally, writes the bitstream to a file (videoFile.264).
- DA RTP Transmitter/RTCP User Agent:
  - receives/processes Audio RTCP Rx User Agent Client Messages.
  - controls the Audio RTCP Tx User Agent User Agent.
  - initializes, manages, and shuts down the Audio RTP Transmitter in accordance with certain system parameters.
  - initializes, manages, and shuts down the Audio RTP Transmitter sockets in accordance with certain system parameters.
  - independently forms the AAC-LC video bitstream into Audio RTP Transmitter packets then transmits them onto the network and, optionally, writes the bitstream to a file (audioFile.aac).

The RTP A/V Streaming Server implements H.264 video and AAC audio streaming in accordance with IETF RFC 3550 *RTP: A Transport Protocol for Real-Time Applications*, RFC 6184 *RTP Payload for H.264 Video*, and RFC 3551 *RTP Profile for Audio and Video Conferences with Minimal Control*.[2]

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[2] For an excellent tutorial concerning the application of RTP, please see the presentation *RTP: Multimedia Streaming over IP*, by Colin Perkins, USC Information Sciences Institute.

RTP A / V Streaming Client Functional Modules

As illustrated in Figure 6, the TMS320DM365 DVEVM RTP A/V Streaming Client component (implemented in `ava_rtp_ts_client`) includes: a thread that implements the RTP Audio Socket Receive, RTCP Video Message Socket Transmit, and AAC-LC File Writer functions; a thread that implements the RTP Video Socket Receive, RTCP Video Message Socket Transmit, and H.264 Video File Writer functions; a thread that implements the Control, MPEG-2 Transport Stream Encode, and MPEG-2 TS File Writer functions; and the `main` function that starts/shuts down the application by initializing/shutting down the application threads.

A short description of each of the CS365-TI DMSDK Ubuntu Linux Host RTP A/V Streaming Client functional modules is presented below:

- DV RTP Receiver/RTCP User Agent:
  - generates/sends Video RTCP Receiver User Agent Client Messages.
  - receives/processes Video RTCP Transmitter User Agent Server Messages.
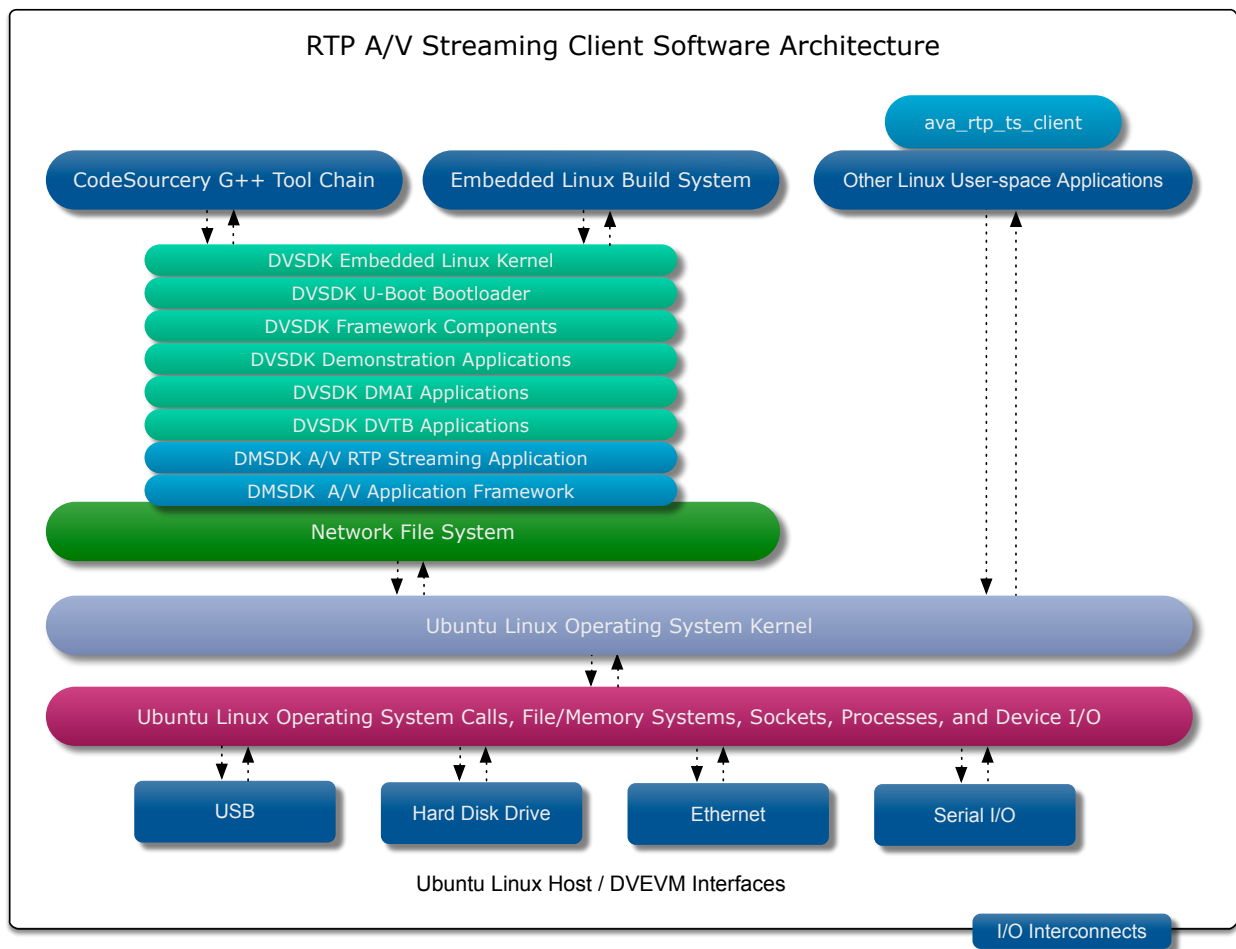 - controls the Video RTCP Receiver User Agent.

Figure 6: RTP A/V Streaming Client Software Architectural Diagram.

  - initializes, manages, and shuts down the Video RTP Receiver in accordance with certain system parameters.
  - initializes, manages, and shuts down the Video RTP Receiver input/output sockets in accordance with certain system parameters.

- depacketizes the H.264 video bitstream RTP packets then transmits the resulting video bitstream to the MPEG-2 TS Encoder and to the File Writer.
- DA RTP Receiver/RTCP User Agent:
  - generates/sends Audio RTCP Receiver User Agent Client Messages.
  - receives/processes Audio RTCP Transmitter User Agent Server Messages.
  - controls the Audio RTCP Receiver User Agent.
  - initializes, manages, and shuts down the Audio RTP Receiver in accordance with certain system parameters.
  - initializes, manages, and shuts down the Audio RTP Receiver input/output sockets in accordance with certain system parameters.
  - depacketizes the AAC-LC audio bitstream RTP packets then transmits the resulting video bitstream to the MPEG-2 TS Encoder and to the File Writer.
- MPEG-2 TS Encoder:
  - creates, multiplexes then outputs MPEG-2 TS SDT, PAT, and PMT packets.
  - creates, multiplexes then outputs MPEG-2 TS H.264 video bitstream packets.
  - creates, multiplexes then outputs MPEG-2 TS AAC-LC audio bitstream packets.
- MPEG-2 TS Output/File Writer:
  - outputs MPEG-2 TS packets.
  - writes the MPEG-2 TS file.

System Requirements

Prerequisites for installation of the CS365-TI DMSDK:

1. An instance of Ubuntu Linux 10.04 LTS running on a PC/Mac—either natively or on a Virtual Machine (VM).
2. DM365 DMEVM must be configurable with Texas Instruments DVSDK version 4.02, i.e., dvsdk_dm365-evm_4.02.00.06.
3. DM365 DMEVM must be configurable with the LI-5M02.

For more information regarding this and other Cimarron Systems products, please contact us using the contact information below.

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Revision History:

Date	Version	Notes
11/15/2012	version 1.0	Initial version.
1/3/2014	version 1.5	Extended AE/WB functions.
4/14/2017	version 2.0	Minor editorial corrections.