Low Latency Systems encompasses those where the exchange of media between two networked end points is critically dependent on the latency associated with data communication. In such cases, media may be communicated both ways or only one-way.

Most real-time interactive video based applications are critically dependent on the end-to-end latency of media processing and media delivery. Low latency video can be used to provide remote control of devices such as robots, cameras or even computers. When talking about such applications therefore, one refers to systems and solutions meant for real-time media content encoding, transcoding or playback.

Evidently, media processing & presentation forms the heart of such an application (media refers to video along with audio, text, metadata, image, speech and graphics data). In a typical system or solution like this, media is transformed/processed (compression / decompression, packet handling, media quality enhancement, I/O device operations, file format handling, security, etc.) and presented to the end user over the network. The challenge is to do it with a latency as low as possible to simulate a close to a direct interactive experience as possible.

Some of the application scenarios where latency is of paramount consideration are illustrated below.

- Screen sharing
- Situational awareness
- Unmanned vehicle navigation
- Industrial robotics (remote control)
- Live Broadcast of Events
- KVM over IP
- Cloud Gaming server and client
- PTZ controlled Network Camera
LL SDK: Introduction

LL SDK is Ittiam’s video networking suite of software products aimed at providing standard technologies for low latency use cases as a software stack on embedded and mobile platforms.

LL SDK is a suite of test-proven technology IPs (explained later) bundled into a software stack that spans media processing / handling and associated control functionality to realize software systems for video networking products. The primary advantages of the SDK are summarized here:

Technology & Functionality Richness

- Best in class latency for a programmable platform
- Patented/ patent pending technologies enabling high performance over different types of network*
- Standards compliant and interoperable solution
- Tested and field proven

Builds on Ittiam’s industry-proven record of delivering high-performance real-time embedded multimedia systems

Two Types of offering

SDK (Media and Application Features) or System Software
(see explanation later)

SDK Advantages

- Standard configs combined with high customizability enabling time to market advantage
- High configurability through easy to use API
- Built in support for portability to custom hardware platforms
- Multiple levels of offering for different customer profiles
Ittiam’s Low Latency Software Development Kit or LL-SDK is based on field-proven software framework that offers time to market, reliability and quality advantage to customers for realization of products involving networking of/via media, especially video...

**LL SDK Advantages**

Ittiam has been a strong player in the domain of video networking for the last decade. Ittiam’s patented software architecture and methodology that forms the basis of LL-SDK. This architecture encompasses software modules, framework elements, utilities, tools and methods to realize networking products to provide a time-to-market advantage.

Coupled with extensive documentation, integration support and quality, LL-SDK delivers extensive functionality to customers as off-the-shelf systems as well as customized offerings for specific applications.

LL SDK architecture has numerous elements of patent pending innovation & design that distinguish it from competition. With field proven IPs and an illustrious history of providing video networking systems to reputed names across the globe, LL SDK also provides a high degree of reliability and performance while offering the best media quality in the industry. It provides standard compliant media and session management stacks, as well as integration framework to realize end-product use cases. The implementation methodology allows the software stack to be easily ported on customer hardware/platforms and even upgradable with third party IPs, if needed.

**LL SDK is available on a host of processors & OS options**

**LL SDK allows easy system integration & customization**

**LL SDK has more than 10 patented design elements**

**LL SDK implements standard-compliant technologies**
LL SDK is field proven enables the realization of real time interactive applications in the following domains…

Latency Critical Applications
Health Care / Medical Systems
Government & Defense Systems
Security & Surveillance Systems

Military and Reconnaissance Systems
Live 2-way communication
Cloud Gaming
Industrial Robotics

Key Technologies For Low Latency Systems

There are many key technologies that make LL SDK a holistic offering that can cater to all the above application classes (based on the deployment environment and product usage). Some of these are listed below:

- **Media compression/decompression** (encoding and decoding in a multitude of formats, allowing configurations to manage quality, latency and rate control constraints, optimizations to operate on multiple types of networks including loss prone ones)
- **Network protocols** (for packet data handling, inter-device connectivity and channel management)
- **Reliable networking** (to enable the end product usage on the network of interest – wired vs. wireless, lossless vs. loss prone, private vs. public, etc.)
- **Media processing** (to transform media using pre/post processing elements like resizing, format conversion, resampling, overlay, deinterlacing etc.)
- **Security features** (to enable the content or data networking to be secure and breach-proof using standard and proprietary methods)
- **Interfacing with I/O devices** (to capture / render media from devices like cameras, players, display units, monitors, etc.)
LL SDK integrates and provides access to a suite of media processing algorithms including encoders, decoders pre & post processing modules for video, image, speech and audio data, along with metadata and user defined data formats.
Ittiam LL SDK can be offered to customers at two types of offerings shown below. Flexible software architecture allows neatly demarcated software APIs for the SDK. These are available on a host of platforms and allow Ittiam to match the individual customer requirements while retaining the time to market advantage.

Selecting the right level of LL SDK for a given customer is usually governed by the following guidelines:

- **System Software**: When the customer intends Ittiam to offer all system software responsibility – ideal for **turnkey offerings**

- **SDK**: When the customer needs controls to customize the offered application functionality or UI (perhaps for their end customer(s)) or intends to develop the application in-house and requires Ittiam to deliver only the core media processing functionality
Features relevant to various applications have been built in as presets into LL SDK to allow off the shelf delivery of standard functionality. These are called Standard Configs of LL SDK. Standard configs can be bundled together into to achieve more complex use cases. These and other Custom Configs can be created for addressing specialized use cases for the application scenarios of interest for customers. Standard and Custom Configs can be made available on one or more platforms (processor, OS).

Three StandardConfigs for LL SDK
LL SDK Availability

LL SDK is readily available on a range of processors & operating system choices. These include industry standard embedded and mobile platforms that are relevant for realization of a low latency application.

Config **SRVR**: Live Streaming Server
Config **PLYR**: Live Streaming Client
Config **TRNS**: Network Transcoder

Defined as a combination of Standard Configs or Standard Configs enhanced with addition features

Example: Low latency server and transcoder Custom Config includes Config SRVR and Config TRNS

Operating Systems

Available on other operating systems on request

Processor / Hardware

ARM, DM8168/9, Ittiam’s neonCaster, Qualcomm Snapdragon
Available on Freescale iMX6, Samsung Exynos, Jacinto J6, nVidia Tegra, x86 on request
LL SDK Standard Configs

Standard configs include transformations of server, client and transcode. Some of these examples are illustrated here...

Live streaming (illustrated for single audio & video channel)

Network Player (illustrated for single audio & video channel)

Network Transcode (illustrated for single audio & video channel)
LL SDK – Package Contents

Pre-built media and application functionalities that come bundled in LL SDK have extensive configuration / customization options that provide the user with immense flexibility.

In addition, LL SDK allows customers to integrate it fast into larger systems, if needed. And the customers who license the SDK in source form also have added support of rich documentation. Customization options exist in terms of Custom Configs (combination of Standard Configs, custom features, proprietary extensions to features and additional modes of operation).

Starting to use the SDK is simple – just load the user manuals and browse for a step by step guidance on how to realize your use case in a quick and easy manner. Sample applications and example reference code help in easy ramp up and integration guides.
Tailoring the SDK for individual customer is accomplished by a flexible combination of build time bundling of features and functionality of interest as well as a sophisticated framework for adding custom code.
As a software development kit, VN SDK offers a modular approach towards bringing up an end product functionality. This includes user interface and board support software as well as the media & application stacks. The software is flexible enough to allow third party or legacy IPs from the customer to be integrated as well. Customers can choose all or a subset of functionality / features that are illustrated in the figure below (see the blocks marked in blue color). As shown here, a neatly demarcated Application Interface Layer is exported to the user / customer. Within the Media Service, all functionality related to media processing & transformations, associated stacks/modules and components is encapsulated. The core data transformations are facilitated by a high performance Media Engine Framework, which is explained later.
In order for video networking applications to be realized, the underlying media functionality typically needs to be combined with session management, device access and control across networked entities. In addition, the functionality supported by the software stack needs to be exported to the user via a set of well defined interfaces that are easy to integrate into UIs, simple to understand and unambiguous in terms of behavior. All this is implemented in the application software of LL SDK.

This is accomplished by two key elements: **Application Framework** & a pool of Services. Each service is an independent functionality that is to be supported by the application. They key services include media service, signaling service, device access service, and system management services - each on which have a well defined interface. In addition, each service is plugged into the application via standardized plug-in methodology, allowing new services to be added in a easy, modular manner. Services are managed by the application framework, which also facilitated inter-service and inter-process communication. There are also pre-defined mechanisms to allow integration of third party network stacks.

**Application Framework – Salient Features**

- **Signaling and Session Management**
  - Protocols like RTSP, SAP, SIP, etc.
- **Networking and Connectivity Management**
  - Management of ports and IP addresses
- **Event Action Framework**
  - Association of events from software or user inputs to be associated with actions (patent pending)
- **Device Access Policy Management**
  - Virtual channels (patent pending) allowing simultaneous access to devices from multiple services
- **Process Management and Inter Process Communication**
  - Framework to enable multi-process architecture
LL SDK System Management Features

- **Exception and Event Management**
  - Enables ease of integration and debug, based on an innovative method (patents pending)
- **Watchdog**
  - Local and Remote System Health Monitoring
- **Resource Monitoring**
  - CPU, OS, Memory and associated resources
- **Memory Management**
  - Across types of memory available in the system

LL SDK comes bundled with a diverse set of system management tools and services that help ensure the system to work reliably and in a performance guaranteed manner at all times. This becomes significant for mission critical or performance critical systems.

- **Configuration Management**
  - Centralized, rule based and designed for ease of simultaneous access
- **Statistics Collection and Reporting**
  - Across all layers and modules, streamlined and syntactically unified framework across the whole SDK
- **Built In Tests (Self Test)**
  - Ideal for reliable performance of hardware and software in mission critical systems
- **Software Versions Management and Upgrade**
- **Key License Management**
- **User Authentication**
A key challenge in supporting a wide range of media transformations is that each use case requires a different data flow or inclusion of different data paths for realizing a use case – something that is addressed by the flexibility of media framework used in LL SDK.

VN Media Processing Capabilities

- **Graph based pipeline or media flow implementation**
- **Inherently multi-channel capable**
- **Efficient scheduler**
  - comprehends processor load, ability to schedule across multiple SoCs
- **Dynamic changes to data path / processing elements**
- **Multicore support**
  - maximizes utilization of cores
- **Complex graph support in the framework**
  - multi-instance, dynamic reconfiguration
- **Portable across processor families and operating systems**
  - proven on a host of platforms
- **Full control over processing elements**
  - Configurability of all processing elements for each data processing path/channel
- **Multi-user simultaneous access to devices**
  - Patent (pending) on design
- **Allows plug in of 3rd party components**
- **Optimized for command latency**
Unlike LL SDK, competitive frameworks neither offer the multiple levels of offering (suited for each user) nor as comprehensive a suite of video networking functionality bundled as predefined / customizable use cases. These limitations often limit the overall time-to-market advantage for customers. LL SDK offers all benefits of these framework or SDK options, while retaining a performance advantage on supported platforms.

In this section, we present some of the key vectors of comparison of LL SDK against some of the competitive software stacks/SDKs for multimedia systems popularly known in the market. We compare these on types of offering, functionality offered as well as the core configurability & usage related options. LL SDK advantage becomes evident from this comparison.

<table>
<thead>
<tr>
<th>Type of Offering</th>
<th>GStreamer</th>
<th>Live 555</th>
<th>Android</th>
<th>LL SDK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Media Functionality</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Media processing components</td>
<td>✓ Subset</td>
<td>x</td>
<td>✓ Platform Dependent</td>
<td>✓</td>
</tr>
<tr>
<td>Media protocols</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Media framework</td>
<td>✓</td>
<td>x</td>
<td>✓ (Stage fright)</td>
<td>✓ (Ittiam’s MEF)</td>
</tr>
<tr>
<td><strong>Application Functionality</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Session Management</td>
<td>X Do it yourself</td>
<td>✓</td>
<td>X Do it yourself</td>
<td>✓</td>
</tr>
<tr>
<td>UI Framework</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Networking Protocols</td>
<td>✓</td>
<td>✓</td>
<td>X Do it yourself</td>
<td>✓</td>
</tr>
<tr>
<td>System Management</td>
<td>X Do it yourself</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>System Software</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>User Interface</td>
<td>x</td>
<td>x</td>
<td>X Do it yourself</td>
<td>✓ Customizable</td>
</tr>
<tr>
<td>BSP</td>
<td>x</td>
<td>x</td>
<td>✓ Platform Vendor Optimized</td>
<td>✓ Ittiam / Platform Vendor Optimized</td>
</tr>
<tr>
<td>Application and Media Functionality</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
## LL SDK & Competition

<table>
<thead>
<tr>
<th>LL SDK Configs</th>
<th>GStreamer</th>
<th>Live 555</th>
<th>Android</th>
<th>LL SDK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live Server (SRVR)</td>
<td>x Do it yourself</td>
<td>✅</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Network Player (PLYR)</td>
<td>✅</td>
<td>✗</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Network Transcoder (TRNS)</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Custom Configs</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functionality</th>
<th>GStreamer</th>
<th>Live 555</th>
<th>Android</th>
<th>LL SDK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Management</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Simultaneous device access by Multiple Users</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Statistics Collection</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Exception Reporting</td>
<td>✅</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Event Management</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Resource Monitoring</td>
<td>✗</td>
<td>✗</td>
<td>x Do it yourself</td>
<td>✅</td>
</tr>
<tr>
<td>Input Validation</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>Logging</td>
<td>x Do it yourself</td>
<td>✗</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Centralized Configuration Management</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
</tr>
<tr>
<td>IPC Framework</td>
<td>✗</td>
<td>✗</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Messaging Framework</td>
<td>✅</td>
<td>✗</td>
<td>x Do it yourself</td>
<td>✅</td>
</tr>
</tbody>
</table>
LL SDK – Case Study 1

**Problem Description**

**Scope:** Software for a multichannel DVR using TI’s TMS320DM6467T processor (Linux OS) and Intel i7 x86 (Ubuntu) connected via PCIe

**Product:** Networked DVR to be deployed in an for a unmanned aerial vehicle

**Key Customer Care-abouts:**
Product Reliability and hardware design consulting

**Challenges:**
- Web based UI from a commercial browser integrated for playback
- Support high density (up to 4 channels) HD/SD video
- Operate at high bit rates (up to 100Mbps)
- Standard and proprietary metadata handling
- High degree of data recoverability and no data loss Pre-event recording
- Robust firmware upgrade on the field
- Self Tests and hardware diagnostics
- Driver optimization for PCI communication between x86 and DM6467T

**LL SDK Solution**

- **Custom Config:** Standard Config SRVR + Standard Config REC
  - Standard as well as several premium features for each config
  - Enables independent control of each channel
- **Customization**
  - Features: Custom metadata handling, NTP based time synchronization
  - Live and file streaming to both operate while recording
- **Performance optimized SDK**
  - Encoder optimization to balance compression quality and bit rate profile
  - Highly optimized to have a low memory footprint
  - High efficiency and throughput PCIe communication
  - Split File Recording to enable robust recording
- **Field Robust**
  - Failure-proof Software upgrade
  - Works with all standard browsers
  - Standard system management features
- **Quality Guarantee**
  - Built In Tests for hardware to enable monitoring of status during deployment
  - Proven to work on custom hardware
  - Strict quality assurance process and tools used for testing and validation

**Success Story**

- Nearing production for a major US customer for military applications
- Proven to work for several days together without malfunctioning
- Ittiam consultation on hardware and system design enabled a quick turn around for the product

LL SDK – Case Studies

LL SDK success story spans across dozens of products for customers who are world leaders in their segments. Illustrious customer testimonials and repeat design wins are evidence of the technical edge, quality advantage and customer support offered.
For customers looking beyond field proven software, Ittiam also brings in a special advantage of also offering in-house hardware expertise. This can help customers to design better systems. Design consultation and use case analysis can optionally be bundled into the VN SDK licensing model for an integrated product oriented view to the customer engagement.

LL SDK – Case Study 2
VN SDK for a Cloud Gaming Client on Android

Problem Description

**Scope:** Software for a multichannel surveillance server product using TI’s TMS320DM6467 processor (Linux OS)

**Product:** Networked Surveillance cameras To be used across Europe to monitor traffic

**Key Customer Care-abouts:** Adherence to IFE content specification, reliability, schedule

**Challenges:**
- Support high density (up to 8 channels) HD/SD video
- Operate for several weeks with very high stability and reliability
- User authentication
- Encrypted media and tamper proofing
- Remote PTZ of cameras
- Alarms and Critical Events
- Robust firmware upgrade on the field
- Backward compatible configuration updates
- Extensive watchdog and resource monitoring
- Interoperability with industry standard clients

LL SDK Solution

- Standard Config PLYR with standard as well as several premium features
  - Enables operation across several audio, video and file formats
  - Integrated operation for multicast streams, VOD as well as local file playback
- Customization
  - Features: Protection against failure of content source and switching to alternate source(s)
  - Interoperability with a custom VOD server
  - Strict adherence to encoding specifications for content
- Performance optimized SDK
  - Optimized to have two channel HD operation
  - Built to co-exist and run along with other standard Android applications
- Architecturally aligned with the customer’s application & UI design for ease of integration
- Integration Support
  - Sample Applications for Use Case Illustration
  - Detailed documentation and integration notes
- Quality Guarantee
  - Strict quality assurance process and tools used for testing and validation

Success Story

- Successfully being deployed across multiple global airlines
- Works reliably across a host of content played back in the IFE playback device
- Integrated with ease into a whole different application and UI as compared the sample application than the one delivered with VN SDK
i think... therefore i am

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