Connected Car - Smart Home

Requirements for a new generation of Infotainment Systems

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Connected Cars

- Are quickly becoming reality and features are a distinguishing factor between OEMs
- How will cars communicate with homes and our phones and tablets
- Automotive Infotainment Systems are obvious candidates for communication nodes
- This poses significant challenges
  - Architecture and Design
  - Platforms, Development Tools and Processes
  - Security and Robustness

Some Typical Use Cases

- You are playing music at home and have to leave the house:
  - Lock the house, enter the car
  - The music “follows” you to the car
  - Picks up where it was left off in the house, seamlessly w/o user interaction

Some Typical Use Cases

- An item was left in the car (wallet, cell phone)
  - A smart home knows where it is
  - This works the other way around, too
- A teenager drives the car
  - The car breaks down, e.g. a tire becomes deflated
  - Smart home is informed, smart home TV facilitates video call with the car's infotainment system

More Use Cases

- Home alarm system was disabled while you are away in the car
  - Message is displayed in the car
  - Video of the home surveillance cameras can be displayed in the car
- You make a restaurant reservation while at home
  - Your car knows time and location of the reservation
  - Has navigation information ready and loaded
  - Understands your calendar and plans the route to pick up potential companions
  - Adjusts the in-vehicle temperature prior to the trip

Intelligent Collaboration

- Very different components of hardware and software
- Purpose is clear: **enhancing everyday life**
- Connecting Car - Home is uncharted terrain because of the proprietary components “Car” and “Home”
- Medium phone as the interface is in early stages (Android Auto and CarPlay)
- Infotainment Stacks should allow for direct connections

Home and Phone Components

- Automotive Components
  - Proprietary, embedded systems
  - Closed (almost) all the way
  - Hundreds of sensors and actuators
  - Center Stack Infotainment System with access to some Telemetry data
  - Internet connected

Home and Phone Components *(continued)*

- Home
  - Many communication protocols X10, Zigbee, Z-Wave, Insteon, Bluetooth Classic and LE, etc..
  - Even more commercial offerings, mostly all integrated
  - No standards for aggregation, most systems interface with mobile apps directly through WiFi and BLE or through “Smart Hubs” (Amazon Echo, SmartThings, Leviton, Nexia, etc..)
  - IoT M2M protocols could help, e.g. MQTT, CoAP, LWM2M, etc.
- Phone
  - iOS and Android app development is easy, cheap, well documented and mature

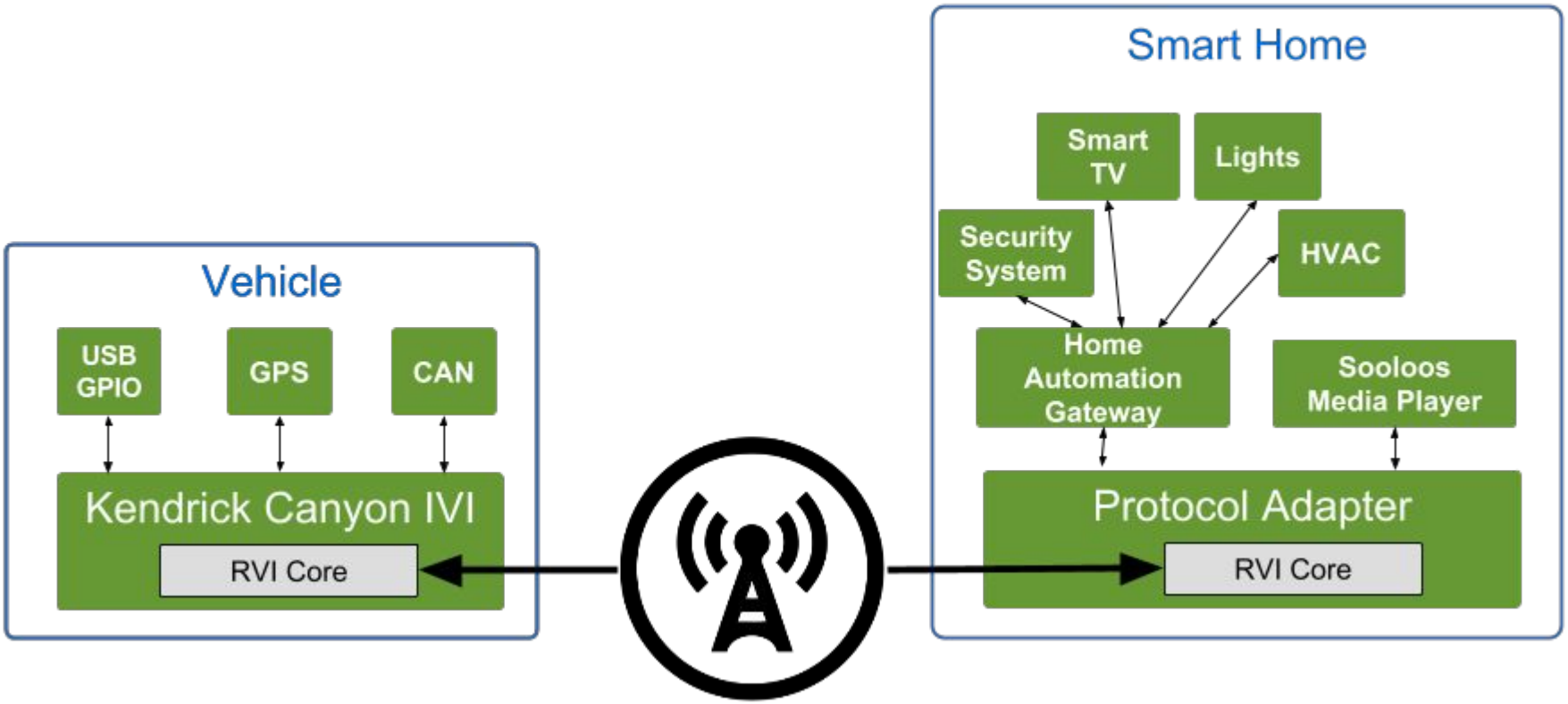
Challenges

- Differences in lifecycles
  - Cars, consumer devices, phones, home automation
  - Different development times
  - Dictated by regulation, consumer expectations: car life cycle (>10 years)
- Automotive and mobile industries have very different objectives
- Consumer acceptance
  - Depends on significant lifestyle improvements
  - Balanced with costs, guided by marketing
- Disruptive technologies
  - Mobility vs. car ownership (ZipCar and Uber)
  - Autonomous cars will pose new opportunities

Standards and Protocols

- Nurturing this ecosystem
  - Means understanding the importance and supporting the development of open standards
  - Or the *basket of remote controls* will doom all efforts
- Automotive manufacturers
  - Working directly with cell network operator (AT&T, Sprint, Verizon, T-Mobile...)
  - Cell phone makers (Apple, Samsung, LG, Motorola...)
- Remote Vehicle Interaction (RVI)
  - Spearheaded by Jaguar Land Rover
  - Adopted by GENIVI as -
    “Open source technology to handle authentication, authorization, discovery, and data exchange between services in a sparsely connected peer-to-peer network”

A Much Simplified Architecture



Prototype Implementation

- ICS developed an In-Vehicle-Infotainment Prototype based on automotive hardware and middleware
  - Modern UI, Plugin based architecture, easily customizable and extendable
- Features a rich Media Stack
  - BYOD Music, Bluetooth Connectivity, Navigation, Rear Seat Entertainment and much more
- Already had remote control capabilities from speech recognition module
- Ideal for fast prototyping of the Connected Car scenario

Media Management

- At ICS we have designed and built many In-Vehicle-Infotainment systems (see e.g. this video)
- When asked to look into Media Management we found this to be a vexing and complex problem
- The challenge for automotive IVI implementations is that
  - People's media -- their music, videos, audiobooks, podcasts and television -- exist in a multitude of forms and originate from many disparate sources.
  - For example, some music files may reside at home in an iTunes library, others may have been purchased from Amazon Music or Google Play.
  - Media may have then been downloaded to a computer, a USB drive or a phone, or stored on a cloud server.
  - Management of digital rights adds yet another layer of complexity to the situation -- one that can't be ignored

Requirements

- The job of finding and making available media to the passengers of a car is that of the Media Manager
- First step: Recognizing a Device is brought into the car
- Next: Finding and Indexing Media on the Device
- Possibly: Enhancing Media Information to allow improved search, filtering, etc..
- Definitely: Playing of Media using the car’s advanced audio systems

Requirements *(continued)*

- Controlling the flow of Media to e.g. different Speaker Zones, Headphones, Videos to headrest screens etc..
  - When multiple occupants drive in the car each individual should be able to enjoy their own audio and video selections.
  - Hence a media manager should be able to direct media to specific passengers.

The Idea - Coding for the Unknown

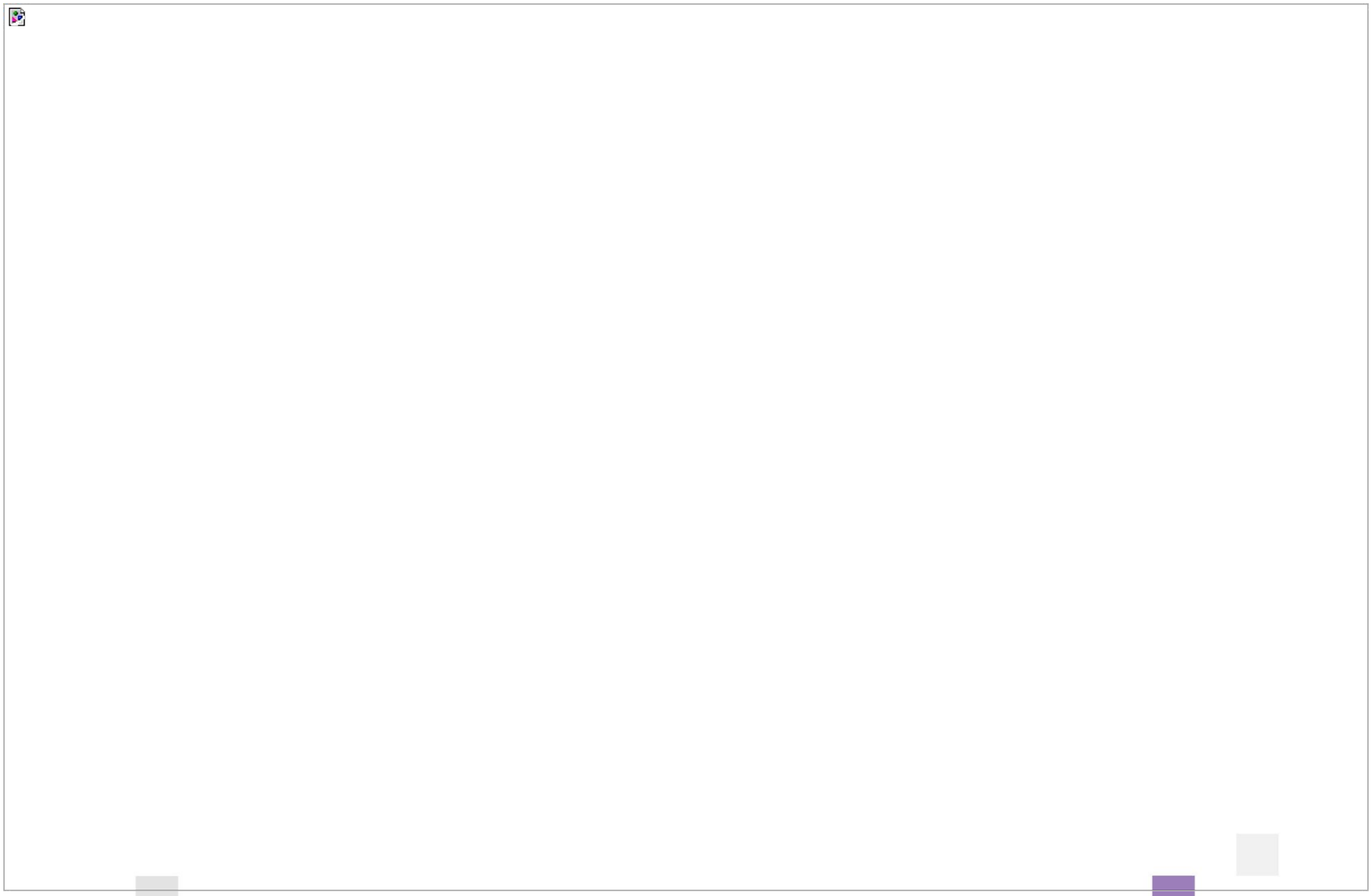
Today's media consumers behavior changes rapidly:

- Remember the "Walkman" - Enjoyed it for Decades
- CDs - Lasted maybe 10 years
- MP3s on CDs, USB Pendrives, Less than 5 years
- Cloud based music sharing, Amazon tbd.
- Streaming:
- Pandora, by all means not saying it's dead but:
- Spotify, is the current Darling (< 2 years)
- What is next?
  - The cycles become shorter and shorter
  - Consumers change phones 2-3 years on average
- We must keep in mind that what we create might be partially outdated by the time is is released - Ouch!

Possible Solutions

- Use a Mobile Phone or Tablet OS in the Car
- Use a Web Technology Based Stack in the Car
- Design an Open Standards based, Car specific OS and create a system of plugins and components with open interfaces that can be easily updated
- Architecture of the ICS Media Manager follows this idea

Architecture

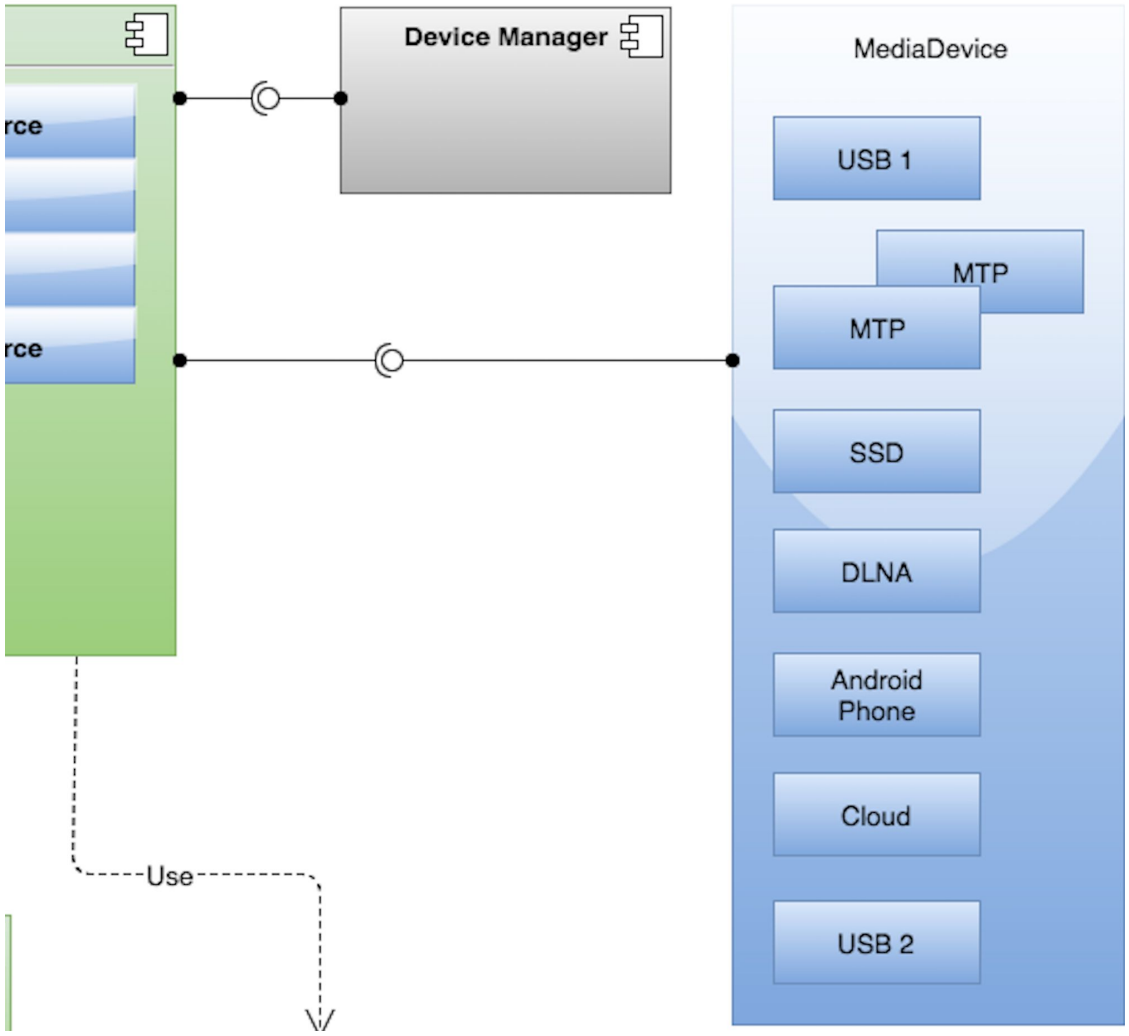


Plugin Architecture

Media Manager Core Functionality

- Load Plugins:
  - Device Manager
  - Media Devices
  - Media Players
  - Services (Audio Manager, Media Enrichment)
  - Controllers (UI, RC, RVI)
- Organize Flow of Media Info Data from Device to Player and Device to Controller

Media Devices

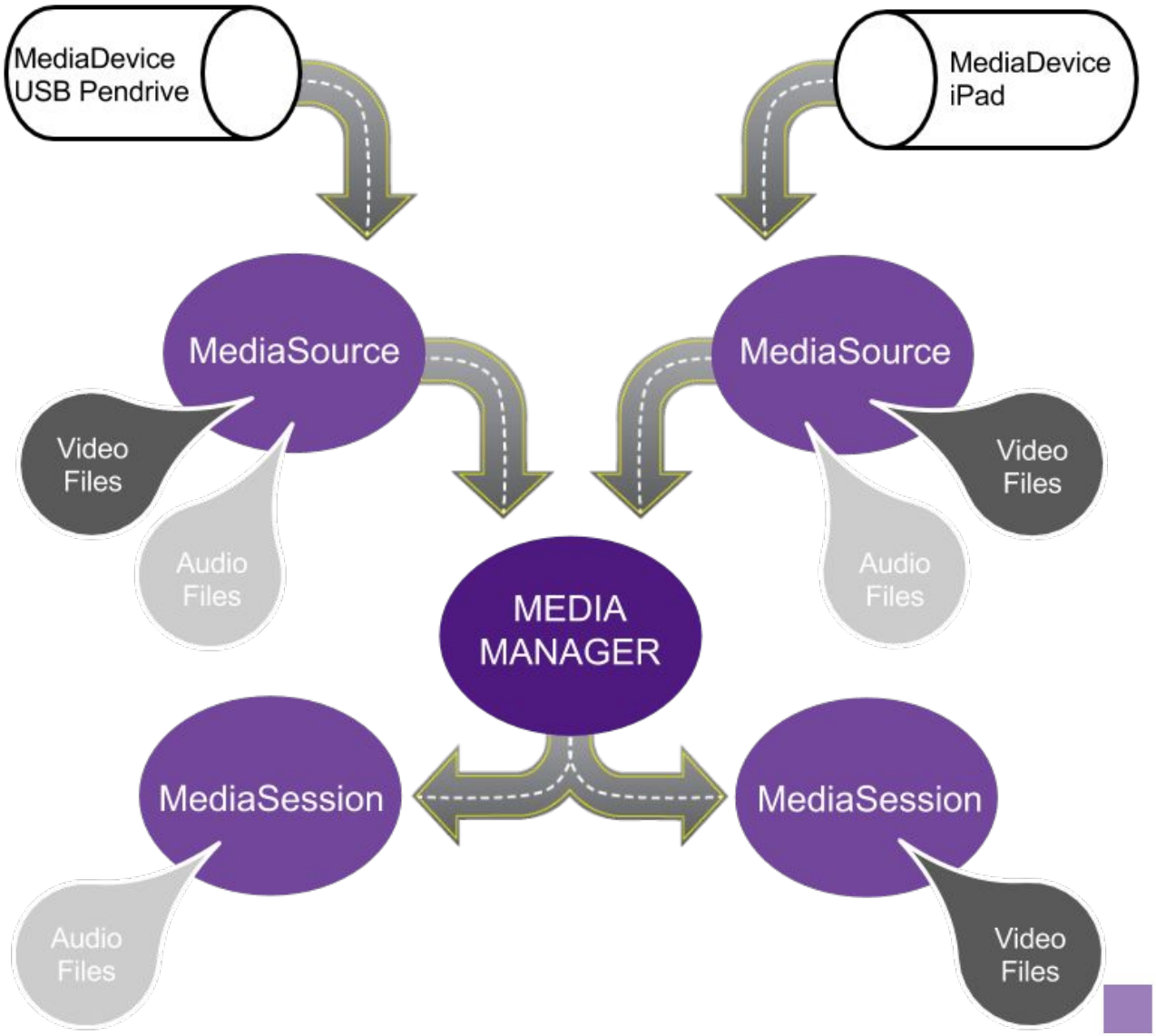


Device Manager Plugin Interface

```
/** DeviceManagerInterface is a Plugin Interface for DeviceManagers
*   that detect MediaDevices which contain Media that can be indexed
*   by a suitable MediaDevice.
**/
class DeviceManagerInterface : public QObject
{
   Q_OBJECT
public:
   explicit DeviceManagerInterface(QObject * parent=0) : QObject(parent) {}
   virtual ~DeviceManagerInterface() {}
signals:
   void deviceCreated(const QString mediaDeviceType, const QUrl mediaDevicePath) const;
   void deviceRemoved(const QString mediaDeviceType, const QUrl mediaDevicePath) const;
};

#define DeviceManagerInterface_iid "com.ics.media-manager.DeviceManagerInterface"
Q_DECLARE_INTERFACE(DeviceManagerInterface, DeviceManagerInterface_iid)
```

Data Flow


MediaDevice
USB Pendrive
MediaDevice
iPad
MediaSource
MediaSource
Video
Files
Audio
Files
Audio
Files
Video
Files
MEDIA
MANAGER
MediaSession
MediaSession
Audio
Files
Video
Files

Core Components

- MediaSource
  - Provide interfaces to devices.
  - Devices are physical media such as Phones, iPads, USB thumb drives, Microsoft Media Players, DLNA, Bluetooth, cloud or any source that can be indexed.
- MediaSource Playlists
  - Each source presents to the media manager one or more source playlists.
  - The media manager takes these lists and add them to corresponding MediaSessions.
  - For example, video playlists are offered to the session that interfaces to a video player, whereas Bluetooth playlists are offered to a Bluetooth Player which in turn controls a Bluetooth device through the AVRCP protocol.

MediaSession and MediaSource

- MediaSession
  - Each MediaSession holds a playlist of tracks specific to a media type e.g. mp3 files, video files or Bluetooth streams.
  - MediaSession interfaces a single instance of a media player for the specific media type.
  - Contains a JSON Object consisting of multiple JSON Arrays,
  - One per MediaType present on the device.
- MediaPlaylist is a JSON Array
  - Each JSON Array contains indexing data
  - Indexing data are JSON Objects,
    - one for each media item
    - containing attributes of a single media item
    - e.g., file names, artists, cover art
      and many other things of interest to the end user

DataStructure: MediaPlaylist


```
{
    "AudioFileMediaType": [
        {
            "Album": "Southernality",
            "Artist": "A Thousand Horses",
            "CompleteName": "/mm_test/audio/a.mp3",
            "Title": "(This Ain’t No) Drunk Dial",
        },
        {
            "Album": "Billboard Top 60 Country Songs",
            "Artist": "Big & Rich",
            "CompleteName": "/mm_test/audio/b.mp3",
            "Title": "Run Away with You",
        }
    ],
    "VideoFileMediaType": [
        {
            "CompleteName": "/mm_test/video/mad_max.mp4",
            "FileName": "mad_max",
            "Format": "MPEG-4",
            "InternetMediaType": "video/mp4",
        },
        {
            "CompleteName": "/mm_test/video/sup-vs-bat.mp4",
            "FileName": "sup-vs-bat",
            "Format": "MPEG-4",
            "InternetMediaType": "video/mp4",
        }
    ]
}
```

Core Components

- MediaPlayer
  - MediaPlayers control the output of media
  - Implement functionality of media reproduction e.g., play, pause, stop, play index, play next, play previous etc.
  - Can also be controlled to direct output to specific channels through an audio manager component.
- MediaManager
  - MediaManager maintains a set of session objects and a set of source objects.
  - Interfaces with an audio manager for audio channels
  - Interfaces with a device manager for device notifications.
  - Provides a controller interface which allows for direct user interface (UI) implementation using the toolkit of choice as well as remote control through RVI or web interfaces.

Media Manager Core Functionality

- MediaSessions store sets of playlists (in JSON Arrays)
  - Identified with the MediaSource they came from
  - It is trivial to update playlists upon removal of a device at the cost of rebuilding the playlist and transferring it to the MediaPlayer again.
  - Use of “implicitly shared” container classes is fundamental to a robust and efficient implementation.

Media Manager Core Functionality *(continued)*

- When a device is connected, e.g. a USB pen drive is plugged in:
  - Media Manager receives a notification from the Device Manager plugin.
  - With the help of a suitable MediaDevice indexing results in a MediaSource object - delivered to and received by the Media Manager.
  - Media Manager stores and accesses MediaSession objects corresponding to MediaTypes contained in the MediaSource
  - Appends the playlists coming from the MediaSource object to the MediaSession.
  - During this step, filtering and sorting can be applied.

Indexer - MediaInfo

- The problem of indexing media is two-fold:
  - Files must be found, identified and the results stored.
  - Media contained in files and streams must be classified.
  - We are looking to answer questions like:
    - How long is this “mp3” file? Who sang this song? Who directed this orchestra?
  - All of this information should be available to the user as fast as the medium permits while preserving an always responsive, modern user experience.

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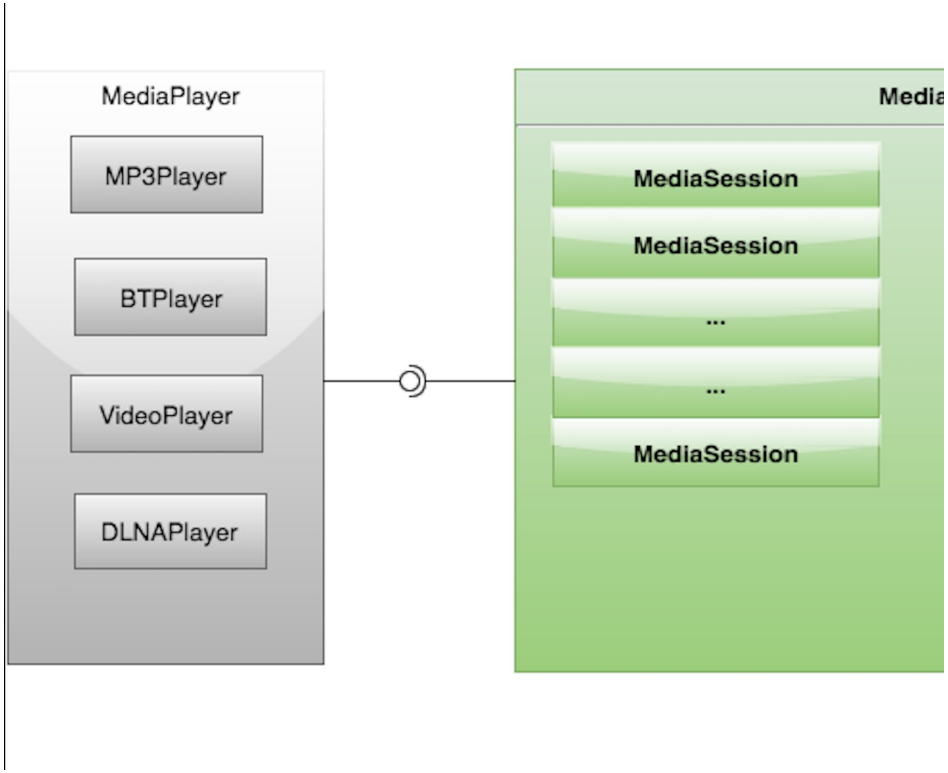
Indexer - MediaInfo

- Notable Open Source indexing solutions:
  - Gnome projects Tracker and KDE's Nepomuk are powerful and complex search and indexing solutions
  - appropriate for desktop solutions.
  - Light Media Scanner (LMS), and FFMpeg project's ffprobe are more suited for constrained environments and use cases.
- Another widely used option is MediaInfo
  - Highly customizable,
  - can easily be integrated in C++ based applications,
  - has support for hundreds of media types and is a fast and robust solution with a long standing track record.
-

MediaPlayers

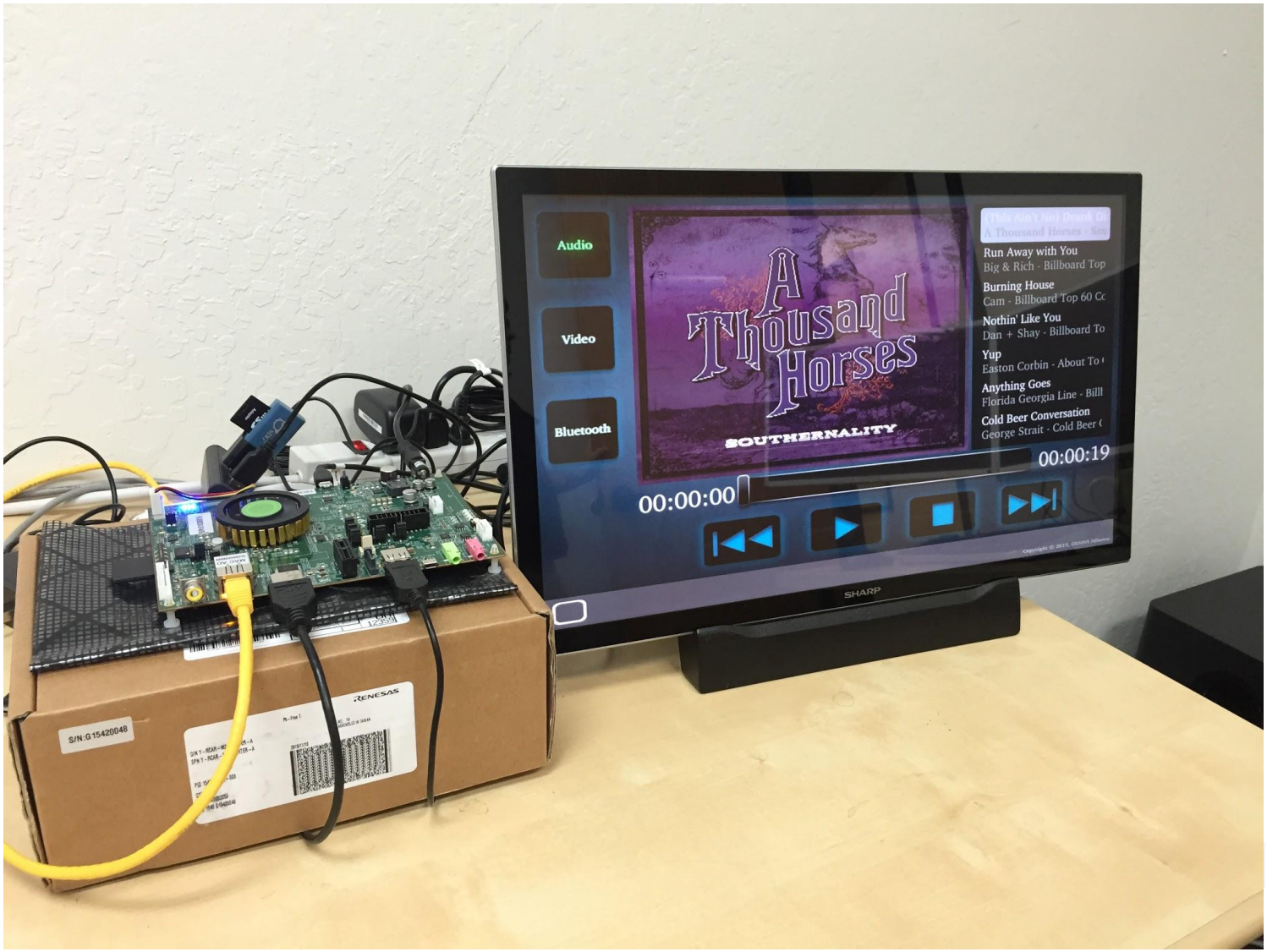
- MediaPlayers do not provide UI control elements!
  - They do however have visible elements
  - E.g. video surfaces
  - Control is through a plugin interface



Controllers

- Media Manager employs the concept of active MediaSessions
  - Control the actual playback of media.
  - It calls the active sessions player with the standard actions of playing
  - E.g. play, pause, next, previous, play by index etc..
  - The control of the Media Manager itself is through a MediaManagerControllerInterface that is implemented by a variety of “stateless” plugins.
  - E.g., a simple UI plugin allows for a graphical user interface to be implemented while a “remote controller” plugin allows mobile devices to control the Media Manager and thus its playing functionality.

QtQuick - UI Controller



Integration GENIVI Development Platform

JSON Rpc Controller

- TCP based JSON-RPC
- Utilizes QJsonRpc
- Implements MediaManagerControllerInterface
- Same Interface as UI based Controllers
- Stateless Controller Architecture guarantees that all Controllers are in the same state
- Signal and Slot implementation allows to add controllers at will without changing the MediaManager code

Currently in Development

- Plugins and Indexers for Phones and Tablet devices - these require mobile apps
- Plugins for DLNA devices
- Plugins for Bluetooth device playback
  - BlueZ, AVRCP and A2DP protocols

What to do for Home Connectivity

- Customized Media Player Plugin
  - RVI client implementation
- Tap into a Car CAN Bus or simply retrofit a car with additional sensors and an IoT Hub
  - Seat sensors notify of occupancy
  - Car notifies home controller
  - Home Controller locks doors turns off lights
  - Home Controller brings video to Smart-TV

What is Next?

- Automotive industry is at the center of a paradigm shift
  - Demand for connected lifestyle is evident
- Must keep up with the pace of developing mobile and home automation ecosystems
  - Automotive industry could separate shareable components from differentiating value propositions
  - Joint development of common, shareable components based on open standards
  - Provides the platform to hold pace with development cycles of mobile industry
- Autonomous mobility will accelerate demand for connected lifestyle

Conclusion

- As the vision of autonomous driving changes the role of the automobile itself:
  - Our Vision is to create software that allows the Automobile to be an integration point for Media
  - Similar to the “Connected Home”
  - Central point where Media “comes together”
- Architecture of our components should not withstand the developments of the future but adopt to it.
- Visit us - Talk to us - Work with us!
- How can we help you?

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We provide:

- Consultancy and services for the automotive industry:
  - Architecture and implementation
  - Middleware components
  - User Interface components
- User Experience Development
  - Workflow engineering
  - Graphics and design services