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Integrating IR into Server-based Control/Automation Networks

Using Inprem^{tm} Server and IR Receivers

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EXECUTIVE SUMMARY

This white paper explores the subject of how to effectively use IR technology in sophisticated control networks, focusing primarily on AV Systems.

It compares intelligent remotes with simple ones that are integrated into systems built on CIWare Labs' Inprem^{tm} Server with LAIR^{tm} technology. It discusses how, in conjunction with IR receivers connected to an IoT backbone via network adapters, such an IR-based system can deliver interesting advantages for users and professionals alike.

LAIR is explained in the context of real systems applications. The benefits and disadvantages of various approaches are discussed, while highlighting practical capabilities and limitations.

Introduction

In recent years, Internet Protocol (IP) has become almost universally available in the home through basic Wifi and wired networks. At the same time, the net cost of building IP connectivity into AV (and other) equipment as a primary protocol for device control is dropping. Overall system control reliability, performance and ease of integration is also enhanced by exploiting IP's bidirectional communication capabilities in multiple ways. The response to this has been a steep increase in IP adoption for control and data as TVs, receivers, and many other AV devices have "gotten smart" and "joined the network." In this way, integration of AV systems is steadily converging with integration of IoT[1].

In addition to simple benefits like knowing for sure that a device is powered on and in the right mode, structured bidirectional communication has lots of future potential, as product developers and integrators find new ways to exploit the ability for all appropriately configured software/firmware that is connected to the network to interact in pursuit of higher objectives[2] and improved user experiences. IP applied to control enables acknowledging commands, and supports self-initiated device behavior with digital messaging, most obviously status. Using the IP network as digital "backbone" clearly enables a much more robust system architecture. New use cases are being created all the time by ambitious integrators and developers, both professional and hobbyists[3]. This is what makes IoT such a technically useful and bountiful business domain to work in.

While IP-based control and data protocols have taken hold in both residential and commercial systems, the age-old standard of using unidirectional infrared (IR) protocols remains for many AV products the only method of control, other than physically interacting with buttons and dials on the device itself. In households that

[1] Internet of Things – See https://en.wikipedia.org/wiki/Internet_of_things.
[2] Usually using the defacto standard REST protocol (Representational State Transfer – see https://en.wikipedia.org/wiki/Representational_state_transfer).
[3] A.k.a., "Do it yourself", or DIY integrators.

don't desire or can't afford expensive control systems, IR is often the go-to approach.

There are a number of reasons; the following are a few:

- Implementing IR is simple and inexpensive, both to as a product feature and as a building block for basic AV systems integration.
- Both IR send and receive require little power, and thus involved components can be battery operated while not requiring frequent battery swaps or recharging.
- IR provides virtually immediate response time.

There are many more reasons why IR reigned for so long, and still remains a major factor today, used by thousands of devices as their primary control protocol. And there are untold millions of IR remotes out there[4]

The above being said, the IR communication protocol is unidirectional, and most implementations rely on a model where only a single command can be sent at a time, in serial fashion. This introduces a number of limitations in what IR can reasonably bring to the task of adding intelligent behavior to a system in the form of improved user experiences.

To offset these limitations, nuggets of intelligence were migrated to the handheld remote, creating the category of "universal remotes." Universal remotes embed a programmable CPU into the remote itself, enabling a "poor man's control system" as it were, without the need for a control server with all the bells, whistles and cost.

In a universal remote, multiple series of IR commands are "blasted" in sequence from the remote itself to multiple devices whose IR receivers are in unobstructed line of sight and distance range of the remote, to achieve the desired system state changes. With the 2001 introduction of Harmony IR Remotes[5], the universal remote came of age, introducing a web-based system to improve programmability and

[4] Many of which are useless without a system like LAIR.
[5] See www.logitech.com for product information, https://en.wikipedia.org/wiki/Logitech_Harmony for history.

share IR libraries online. A "scene" like metaphor based around the concept of "activities" reduced the need for users to worry about what was really happening under the hood in live operation. An "activity" in this context represents a multi-device system state that corresponds to the user's desired mode of AV consumption, usually in a specific room, e.g. "Watch a DVD" or "listen to music".

For those who were not ready to bite on an expensive and complex multi-device AV integration project[6], Harmony and other intelligent remote schemes provided a way to reduce cost and reduce the cognitive load imposed on the user to deal with, in varying degrees of detail, the following use case:

- Find and handle multiple physical IR remotes;
- understand the user interfaces of several devices, their modes, and their interconnections enough to set the stage for rendering media when and where desired;
- memorize sequences of remote keys/commands on different remotes, all required to be correctly navigated to get to where you can watch the evening news[7].

With all due respect to what was definitely a nice improvement in usability, universal remotes, using IR protocol, are most practical when tied to equipment present in the viewing room, so as people's tastes transcended the notion of single room AV towards a basic desire for multi-room systems, and even distributed AV, universal remotes as a tool for building up that level of systems control were often awkward.

There are other issues as well that arise from there not being an accepted universal standard for how the encoding and decoding of IR (analog) light is modulated to carry digital data.

As AV devices have become more intelligent and capable, IR's glory days of being used as a core foundation for AV remote control seem to have waned.

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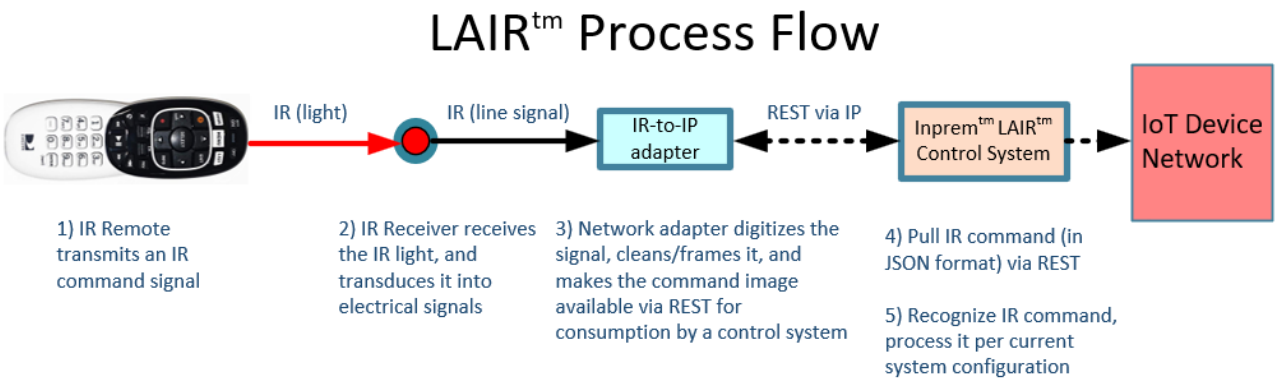
[6] Millions of AV system customers, as it turned out.
[7] Anecdotal evidence has convinced the author that this pejorative view is shared by many users who use the "basket of remotes" approach as their control system.

LAIR^{tm} System Overview

This paper discusses an architecture where IR commands are intercepted in a general purpose IR receiver and then interpreted by a server-based control system, using CIWare Labs' LAIR^{tm} software, which is built into Inprem Server[8], in conjunction with Global Caché IR receivers[9]. This helps integrators transcend beyond blasting IR directly to individual devices in nearby locations, or adding on accessories to build up IR networks.

The basic architecture of a LAIR system is depicted below



The essence of the LAIR process is:

1. An IR remote transmits an IR command, typically by a user pressing a button on the remote. This triggers analog IR light to be modulated in a specific pattern that represents the digital command.
2. An IR receiver located in proximity to the transmitter (remote) receives the modulated analog IR signal[10].
3. The IR receiver's network adapter[11] decodes the analog IR command pulsed signal into digital form, and during that process cleans it up into an atomic digital bitstream that is suitable for recognition in software.

[8] Inprem Server comprises the primary software in the Inprem Studio product. Server is a modular and embeddable control/automation system. See www.ciwarelabs.com for more information.
[9] See www.globalcache.com
[10] The maximum range of pulsed IR is usually within 30'-40', with unobstructed line of sight.
[11] Currently supported by Global Cache's Connect product, via the GCIR3 module

4. The new facsimile of the original command is then wrapped into a JSON data object, which is in turn transmitted to Inprem Server via HTTP/REST protocol.
5. Once received, Inprem[tm] Server's LAIR[tm] module attempts to recognize the command. If it matches a valid input command, the command unique identifier is passed on to the mapper, which creates a context based on the configuration, and passes the command and context into the execution pipeline to be carried out. If the command is not recognized, the attempt can be logged for debugging purposes, or just ignored.

Context in LAIR[tm]

LAIR context provides a data dimension that can be applied to improve user experiences in an IoT style AV network. Examples of context in LAIR include:

- An individual device
- A group of devices
- A single room
- An entire project site.
- A set of devices on a specific floor.

LAIR's contextual mapping capability is extremely flexible, so there are many other ways that context can be created and combined in various application scenarios.

Execution Pipeline

Once the contextual mapping step is complete, the command is sent to the Inprem Server execution pipeline, where the command is mapped to an intent[12] based on the current configuration. This intent is then directed to programmed behaviors based on the context provided by the mapper. This can involve one or more devices, with the required commands queued for execution, as either synchronous or asynchronous operations, or any combination thereof, based on the most effective sequence for achieving the intent triggered by the original IR command.

[12] An "intent" is a way of specifying a goal in terms of logic. In control systems, which are inherently distributed, successfully achieving a desired state amongst a variety of interconnected/related devices may be highly probable, but it is never 100% certain.

Implications for Developers/Integrators

In Inprem[tm] Server, IR devices, AV devices, and associated command libraries are managed in similar fashion to many other control systems. The manual[13] processes involved in building up site structures, device data, connections, and other details should be familiar to most CI's who configure and program systems. Inprem Server has a number of built in tools downloading/importing IR libraries from a variety of sources and formats[14], and for learning, organizing, and testing them.

Simple Configuration-Only Use Case (no programming)

Although mapping and execution in LAIR is built on a sophisticated set of underlying and interconnected technologies, the LAIR process described above does not inherently require programming; it can be done entirely with configuration via the site data structure, by configuring devices to be attached to specific locations within the structure, and specifying contextually enhanced intents. The linking of straightforward intents like "turn on a receiver" is a simple example of an intent that can be triggered without programming, as can "initialize this room for streaming Netflix"[15].

Enhanced Operation Using IAL Programming

For more elaborate control scenarios, IAL (Inprem Automation Language) can be brought into play to further refine and adjust system behavior. An example of initializing a single source AV distribution setup could be something like:

1. Check whether the AV distribution system is up and ready to send AV to the distribution network.

[13] But technology-assisted.
[14] Including Global Cache's Control Tower online database (https://irdb.globalcache.com/).
[15] Assuming the primitive behaviors are already programmed in the system to carry out this multi-device intent.

a. (If already on, skip this step) Turn on the media center for general distributed AV, an intent involving multiple devices.
    i. Turn on the audio amplifiers and set their output volumes to zero to avoid transients or unanticipated sounds.
    ii. Turn on the AV source, wait for confirmation that has completed.
    iii. Turn on any other AV distribution equipment required, wait for confirmation that has completed (or wait a predetermined adequate time period)
b. Turn on and initialize target room(s) AV renderer(s), e.g. television(s)
c. When TV(s) are on, enable the home AV source, for selecting content. This could include, for example a soothing background system audio piece that loops.

2. When a user selects content to play, set up the content, start the play action, and gradually ramp up the volume to default level, or a preset.

Using LAIR™ with a single remote AV node, the above initialization could be mapped to a user clicking a single button on an IR remote, within the context of the room where media is to be consumed. The user would use the remote to navigate and select the desired media, and then click on Play, which would perform the smooth transition to the desired media. When switching to different content, a smooth return to background audio could be included, while browsing for the next content.

In a common "best practice" integration scenario, the above would be mapped to the "Power On" button IR codes of all IR remotes in the house. Any IR remote, regardless of brand or model, would then initiate the same action if used in this particular room. The same setup would trigger similar system behavior to occur in any other similarly equipped room.

The ability to program AV control for this type of smooth and simple user experience can be done in various ways with various control systems. With LAIR, almost any IR remote can be utilized in an intuitive manner to achieve elaborate systems control, with minimal button-clicking.

Why IR?

The venerable IR control method could be described as pretty dusty, given the advent of "fancy"[16] remotes in recent years. In addition to pure touch screen devices, some remotes now support combinations of buttons and touch UIs, voice recognition and extensive programmability. But simpler IR remotes, with or without LAIR™ in the mix, still provide a number of advantages for end users, manufacturers and integrators. A few of these are discussed below.

Cost

Simply put, fancy remotes with awesome features typically are quite costly. Fancy remotes cost hundreds (sometimes many hundreds) of dollars per remote. Buying multiple such remote control devices to have in different rooms that need them scarily multiplies the cost.

IR remotes CIWare Labs has tested for usability and battery life can be obtained for under $10 per remote. Often, obsolete but wonderful remotes can be purchased for a tiny fraction of their original cost. One remote we really like in terms of feel and keyboard layout was manufactured by DirecTV years ago. Today, a typical price for this great remote, which even has separate power on and power off keys, is $9.95 – for two!

[16] Catch-all term for modern remotes that go beyond single-key initiates a single IR command, or use wireless communication to bring sophisticated bidirectional features to the handheld remote.

Battery Life

An IR remote's useful battery life can be years with moderate usage. Fancy remotes with visual displays are typically a fraction of that, and they need to be regularly recharged. Same with touch screens and smart phones.

Usability, Performance

For one thing,, hand held remotes are familiar to people for control. A well-designed IR remote provides a tactile user experience that allows easy control from feel, in the dark, without even having to look at it. For those users who like to couch surf or bed surf, it's hard to image an easier way to do it, assuming the remote has adequate functionality so that the "basket of remotes" problem doesn't rear its ugly head.

Fancy remotes and touch screen devices, addition to usually incorporating non-tactile or hybrid UIs[17], can increase user cognitive load by adding multiple interaction methods[18] to achieve a single desired result. For example, the room you are consuming AV in typically needs to be selected before using even the fanciest remotes. With smart phones, the control app itself needs to be located and launched before you can use it, THEN you have to select the current room. Other fancy remote issues can include:

- Battery condition
- Weight
- Fragility
- Complexity of UI programming

RF, Wifi Issues

Using RF can be problematic in multi-room scenarios sometimes, e.g. the effective range from remote to the receiving device. As remote battery power diminishes, this problem can get worse, and, as described above, fancy features use more juice.

[17] An example of hybrid hand held remote would be one that mixes touch screen and hard buttons, or voice and other UIs in the same package.
[18] Including the need to launch an application, probably right when you just got a phone call.

An advantage of RF in remotes, is the ability to walk around and issue commands from anywhere. The downside, as described earlier, is that using RF or Wifi protocols are often not capable of *automatically sensing* what room you are in, which leads to more user interaction to discern that. And what happens if you forget to change the room when you are turning the volume up in a distributed AV scenario?

Why LAIR^{tm}?

The LAIR approach has a number of interesting characteristics that lead to advantages for users, integrators and product developers. A few are covered below.

All the benefits of using IR Remotes without LAIR (see above section)

Ability to automatically detect user's location

Since IR using LAIR with Global Caché network adapters detects the install location of the receiver as part of the digital communication, this data can be applied in configuration and programming of the system. This, in conjunction with Inprem's other contextual capabilities, increases how a CI can create unique and accommodating user experiences that reduce their cognitive load[19], without the need to purchase (expensive) fancy remotes, or unduly complicate the overall system design.

Ability to create fleets of identically performing IR remotes

Each remote in the house can be used in any room yet perform the same. Lost a remote? Just pick up another laying around, or buy 2 new favs for $9.95 on Amazon. You could have 8 remotes in the house instead of a single $800 RF remote that can only be in one place at a time, for 1/20 the cost! And not have to select what room you are currently in whenever you move around…

[19] If you're REALLY good, it might even please them 😊

Ability to mix different IR remote brands/models

With LAIR, it is easy to map the codes of any remote in the house to be interpreted in the same way. Shop for inexpensive IR remotes that have the best layout and tactile feel…

Ability to log all command activity

Since all IR commands are processed by Inprem Server, activity can be selectively tracked at any level of detail for system debugging and monitoring usage (e.g. by your customers' children).

Summary

This white paper has attempted to provide an in-depth exploration of LAIR™ for the purpose of evaluating its potential as a tool for AV and IoT integration.

In pursuit of brevity, IR as typically used in AV systems scenarios has been the main focus here. IoT, by its very nature, is based on IP interfacing to devices, either directly or through network adapters. But it is important to consider that IR remotes, being tied into IoT networks via IR receivers and network adapters that are controlled by Inprem Server, can utilize virtually any IR remote to perform any command sequences, to invoke scenes, and to trigger any programmed action in any connected device.

So it is an interesting idea to explore the potential uses of LAIR in non-AV scenarios as well. Theoretically, you could get a lot of user control bang for the buck.

We at CIWare Labs assert that IR should be considered for device and system control alongside fancy input devices. Re-purposing old technologies can be a good thing!

FOR MORE INFORMATION

Visit www.ciwarelabs.com for more information about Inprem™ Studio, Server, and LAIR™ .

Visit www.globalcache.com for more information about their IR receivers and network adapters.