# ARTIFCIAL INTELLIGENCE IN CABLE TV APPLICATIONS

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*Abstract*

*After many years and billions of dollars invested in a digital network infrastructure the cable TV industry finds itself unable to fully capitalize on that investment. Underpowered set-top-boxes, daunting integration issues, lack of standards, and huge capital costs hinder the roll out of new subscriber services at a time when competition from digital satellite providers is becoming acute. Fortunately, artificial intelligence (AI) technologies developed over the last forty years are directly applicable to many of the difficult technical problems faced by today's cable TV applications. Specifically, we describe how AI techniques can be applied to provide more personalized subscriber services, alleviate information overload, reduce backend server and human editorial costs, and to use available bandwidth more efficiently.*

## INTRODUCTION

The cable TV industry has invested huge sums of capital in recent years to upgrade both their networks and millions of consumer premises equipment (CPE) units from analog to digital. This has not only increased the quantity and quality of video that can be provided, but also placed a system controlled computing device, the digital set-top-box (STB), in every subscriber home. This high-speed, two-way network combined with a re motely programmable computer in the home provides the cable TV industry an opportunity to provide subscriber services that both Microsoft and the digital broadcast satellite (DBS) providers must envy.

Unfortunately, the evolutionary nature of the digital upgrade process has produced an architecture that is ill designed to support the multiple application services that are currently in development or on the drawing board. Initially, the STB was primarily intended to do little more than decode MPEG video. But the abundant bandwidth that the digital upgrades provided allowed for rapid growth in the number of video channels, far too many for the analog style scrolling guide to be practical. The need to overcome information overload caused by too many channels in a scrolling guide drove the development of the interactive program guide (IPG), a remote-control driven application that was squeezed into the confines of the STB. Today, a new set of business needs and opportunities drives the development of an array of new subscriber services, including video-on-demand (VOD), T-Commerce, information-on-demand (IOD), PC-like messaging, and games.

Clearly a STB that was originally intended to do little more than decode MPEG video is hard pressed to support all of these services. Further, the software architecture of the STB, which modified to support a single application (the IPG), typically requires costly integration to accommodate new applications and services. There are no standards for new services. As a result, most new services require costly servers to be deployed at the cable headend to perform much of the work, while the subscriber's STB acts as merely a dumb display device.

This current state of affairs is unfortunate. Because of the economics of the situation, the currently deployed STBs are likely to remain in the field for many years to come. Yet the technical limitations of both STBs and IPG applications impose significant integration and development challenges that impede the roll out of new, high-revenue generating services.

Surprisingly, there is an existing technology that could be applied to currently deployed STBs facilitating the full realization of the revenue potential enabled by a digital cable TV infrastructure. Even more surprising, this technology is neither proprietary nor a recent development. Rather it is the often misunderstood and under-utilized fruit of many decades of academic research: Artificial Intelligence (AI).

While popular understanding of AI revolves around jerky robots and giant, chess-playing super-brains, the true foundations of the science of AI consist of a cornucopia of techniques for performing complex tasks, such as user modeling, application of expert knowledge, dealing with uncertainty, etc. using limited computing resources. Many AI techniques are ideally suited to solving some of the most vexing problems in today's cable TV applications, and can often do so in the restricted computing environment of currently deployed digital STBs.

Carefully applied AI technology promises to revolutionize the subscriber services cable TV can offer, and to do so at a fraction of the cost of conventional, client-server systems.

## EVOLUTION NOT REVOLUTION

The evolutionary development of today's cable TV infrastructures and applications is characterized by the *reactionary loop*, depicted in Fig. 1.

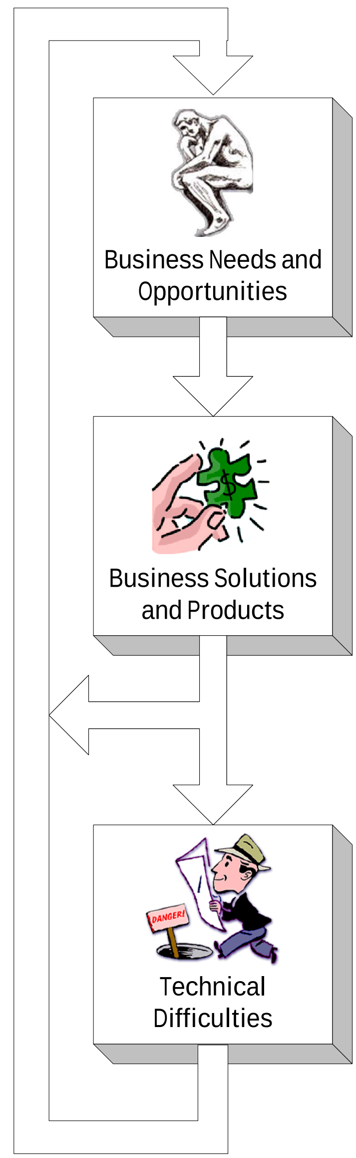


Figure 1. The Reactionary Loop.

Initially, a system operator or multi-system operator (MSO) identifies a business need or opportunity that solves a business problem (e.g., increases revenue, cuts costs, provides competitive advantage, etc.). The MSO then designs or purchases products or technical solutions that satisfy the need or capitalize on the opportunity. Finally, the product or solution reveals new opportunity, or technical difficulties, thus driving the next reactionary cycle.

Unfortunately, this mode of development produces ever more complex and costly, ad hoc solutions, as each cycle must accommodate the shortsighted decisions made on previous cycles. And the resulting solutions typically have little or no intercompatibility without costly software integration.

This state of affairs has led many MSOs to seek a “middleware” solution that provides a common foundation for future application and service development. Unfortunately such systems can never entirely overcome the inadequacies of a hardware and software architecture that has evolved via the reactionary loop. Middleware solutions isolate applications from the raw features available on the STB, forever limiting the role of such code to simple display tasks, and locking solutions into a client-server model. And while limitations imposed by underpowered STB hardware can be alleviated via backend processing, this only trades one problem for others, as this adds yet another layer of computation in an already tight STB environment, and server-centric backend solutions are notoriously expensive, and do not scale well for large numbers of subscribers.

## THE CURRENT CYCLE

As of January, 2003 there are only a few markets in the US providing next generation services on modern STB hardware; the majority of cable systems, by far, are run on old technology.[1] To date, the majority of deployed cable TV STB software is not middleware based, but built around a single resident application, the IPG[2]. In some cases (e.g., DCT-2000) deployment of a new application requires direct integration with the IPG. In most systems out-of-band (OOB) bandwidth is a precious commodity, and little if any is available for use by third-party applications.

In this environment the cable TV industry faces a number of challenges, including high rates of digital churn, slowing digital penetration, shrinking subscriber bases, and the ever increasing competition of DBS. To continue to grow and survive the industry has entered the next cycle in the reactionary loop, as illustrated in Fig. 2. First, several critical business needs have been identified, including:

- Reduce digital churn rates, providing sufficient services to keep digital customers once they sign on.
- Compete with DBS by providing feature parity and significant feature differentiation, capitalizing on the two-way network.
- Create new features and services that can provide incremental revenue (e.g., pay-per-view).

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[1] Primarily from the Motorola DCT-2000 and the Scientific Atlanta Explorer 2000 families.

[2] Mostly TV Guide/Gemstar or TV Gateway.

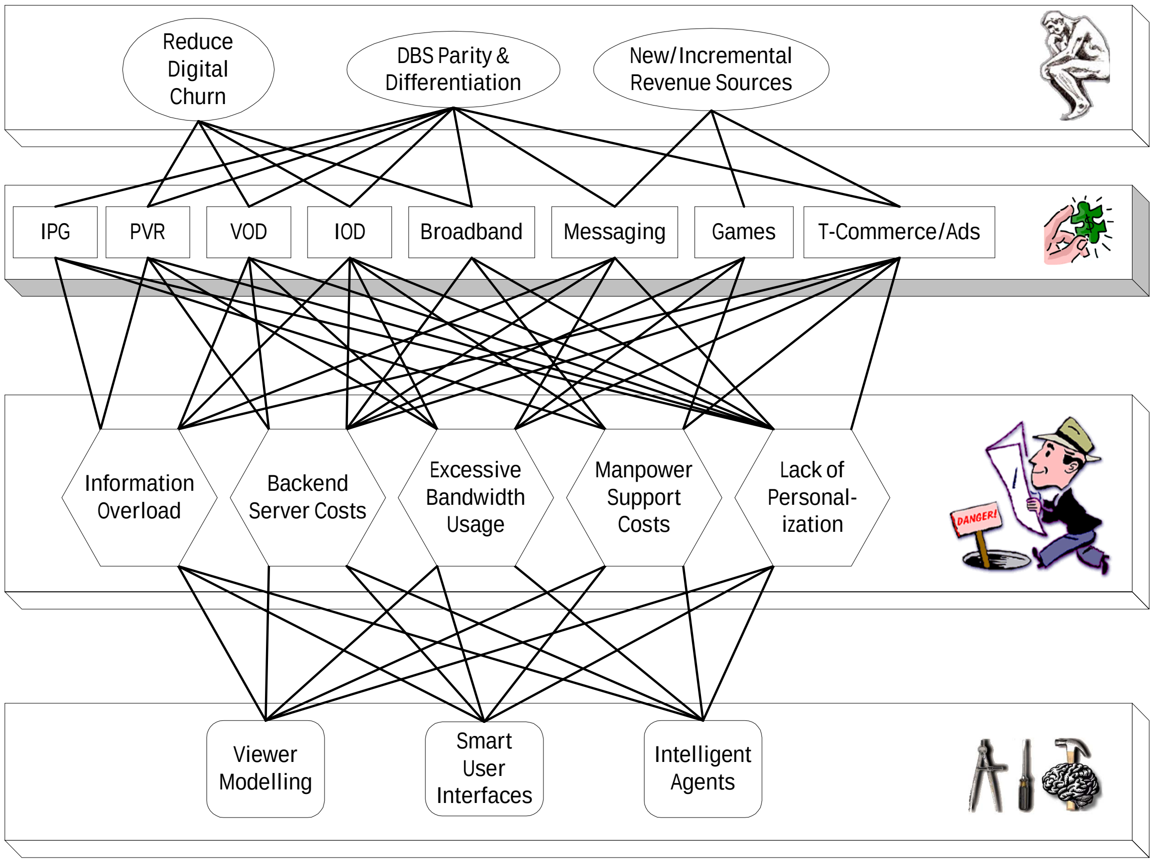


**Figure 2. The current reactionary cycle, and the application of AI tools**

To satisfy these business needs, a variety of new features and services have been defined and in some cases deployed. Among them are:

- **Video-on-demand (VOD)**. Providing TV programming of the subscriber's choice (initially PPV movies) anytime.
- **Information on Demand (IOD)**. Providing relevant news, weather and other information on TV anytime.
- **Messaging**. Providing instant messaging and e-mail services on TV.
- **Games**. Providing games and other interactive entertainments on TV.
- **T-Commerce/Advertising**. Providing custom adverstising and enabling online sales via TV.
- **Broadband Access**. Providing Internet service via cable modem.

However, we believe that such services, even if successful, introduce a number of new technical difficulties that must be overcome for these services to be adopted by subscribers, and to generate the revenue that justifies their implementation costs.

**1. Backend server costs**. As stated above, most such services are implemented via expensive hardware and software deployments at the headend. And while such solutions may work adequately when rolled out, they seldom scale well with the number of subscribers, and may fall victim to their own success.

**2. Excessive bandwidth usage**. It is the nature of such client-server solutions that information has to flow back and forth between client and server. Often this information (e.g., clicks on the remote control) must be transmitted out-of-band. But out-of-band bandwidth is a precious, contention-based commodity, and is often inadequate to the requirements of client-server solutions.

**3. Information overload**. Today's interactive program guides are useable for the several hundred channels available on digital cable. But how can they hope to cope with hundreds or even thousands of new programming titles made available by VOD. The subscriber will suffer information overload, hindering their ability to find and purchase VOD programming. Similar problems exist with the other new services that flood the subscriber with unprecedented quantities of information and numbers of choices.

**4. Manpower support costs.** Many new services, particularly IOD, games, T-Commerce and advertising require a significant number of people to provide content retrieval and editorial services.

**5. Lack of Personalization**. All of these services would be both more useable and more successful if they were personalized for each subscriber. Tailoring the information presented to the subscriber based on their interests and preferences provides a more efficient, and therefore more profitable, user experience. Research has also shown that systems that require personalization or learning are more sticky, retaining customers better than those without. [5]

Fortunately, AI can be applied to solve all five of these problems, and at a fraction of the cost of conventional, client-server systems.

## APPLYING AI TO CABLE TV

Over the past forty years AI scholars have researched a variety of hard problems and developed a vast array of techniques, technologies, and tools for solving them. Serendipitously, most of this research was performed in an era when computing resources were scarce, so even a conventional cable TV STB is often adequate for their application. Table 1 lists several such technologies. [1,3,4]

Implicit in this discussion is that the judicious application of efficient AI technology allows much of the work that is currently performed by backend servers could be performed in a distributed fashion, directly on subscriber STBs, thus eliminating the need for costly backend servers. Such systems have been realized and are in operation today.[2]

| **AI Technology Class** | **Specific Techniques** | **Description** | **Cable TV Applications** |
|---|---|---|---|
| Learning | Rote Learning, Inductive Learning, Neural Networks, Genetic Learning | Incremental improvement of task performance based on rote knowledge or examples. | Modeling the viewer based on previous actions to predict programming of interest for PVR or smart IPG. |
| Intelligent Agents | Information Retrieval, Knowledge Management, Commerce | Software that understands a complex task well enough to automate it, performing in a human role. | Automated content retrieval, reducing editorial staff for IOD, T-Commerce. |
| Expert Systems | Rule-based, Logic-based, Context-sensitive interfaces | Software that can apply expert domain knowledge to a problem. | Encoding knowledge about TV usage to provide smarter user interfaces. |
| Statistical Reasoning | Fuzzy Logic, Certainty Factors, Dempster-Shafer Theory, Baysian Networks | Reasoning with uncertain, incomplete, or noisy input | Widely applicable techniques useful in learning, agents, and expert systems. |
| Distributed Computing | Intelligent Agents, Edge-based computing, Peer-to-peer networking | Distributing pieces of a complex task among several distributed computers. | By pushing tasks down to the STB, obviates need for expensive servers. |

**Table 1. A sample of AI technologies applicable to cable TV applications.**

It is beyond the scope of this paper to describe every possible application of AI technology to the cable TV industry. Instead, we will focus on three sample AI tools, each of which is directly applicable to many of the technical difficulties identified above. These tools are summarized in Table 2.

Intelligent Agents

Intelligent agents are small, active software components that understand a complex task sufficiently to assist a human in performing it, or to automate it entirely. One such task required of IOD and T-Commerce systems is the retrieval of content (text and pictures) to be displayed to the viewer, such as news, sports scores, stock quotes, current bargains, etc. Conventional solutions employ a staff of human editors who retrieve raw content from various network sources, revise it for display on TV. All such data is then broadcast out to the STBs for display. But it has been demonstrated that such tasks can be performed by intelligent agents running directly on the subscribers' STBs.

This approach has a number of advantages. First, it reduces or eliminates the need for an editorial staff. Second, it allows STBs to retrieve exactly the content that is appropriate for a given subscriber, and ignore everything else. This represents a significant reduction in the bandwidth requirements and often allows an on-demand request model to replace the broadcast model currently in use.

| AI Tool | Applies to | Info. Overload | Server Costs | Bandwidth Usage | Manpower Costs | Lack of Personalization |
|---|---|---|---|---|---|---|
| Viewer Modeling | IPG, VOD, IOD, PVR, T-Commerce | Fewer programming or product choices | Runs on STB | No client-server network traffic | -- | Customize views and content to target subscriber interests |
| Smart User Interfaces | All products and services | Automat or assist in obvious or repetitive tasks | Runs on STB | No client-server network traffic | -- | Customize features & views based on subscriber abilities and context |
| Intelligent Agents | IOD, Broadband Portals, T-Commerce | Retrieve and display custom info., not everything | Runs on STB | No broadcast of generic info. Allows on-demand requests | Reduce or eliminate content editorial staff | Select agents that retrieve only desired content. |

**Table 2. Three AI tools and their applicability to the current reactionary cycle**

Smart User Interfaces

Current cable TV user interfaces (e.g., VOD, IPG, IOD) tend to be static, providing the same set of capabilities to all subscribers at all times, regardless of the situation. The user interface, in this case, provides a means of operating a tool. However, significant AI research has been devoted to producing smarter interfaces, that operate more like an automated assistant. Rather than displaying a channel grid in numerical order, a smart IPG interface might order the channels based upon frequency of use. Or, by applying statistical reasoning and expert systems a smart IPG would "understand" the normal activities that a subscriber performs, either assisting or performing those activities automatically.

Viewer Modelling

Information overload is perhaps the most prevalent problem that results from the array of new subscriber services in the works today. Using an IPG to navigate through hundreds of channels is difficult enough. But add thousands of VOD titles and no subscriber is going to want to navigate through any static hierarchy to find a title worth paying for. However, by applying several statistical reasoning and learning techniques from AI, STB software would be able to monitor the programming viewed by a subscriber and construct a model of the tastes and preferences of that subscriber. Armed with this model, a smart IPG or VOD user interface could present the user with a small number of choices tailored to their preferences, and to provide a more dynamic navigation through the available titles based on subscriber tastes. By overcoming the information overload problem, and making it easier to find and buy programming of interest, such systems should allow VOD to realize its true revenue potential.

## SUMMARY

The evolution of technical advances in the cable TV industry is the result of a reactionary cycle. As a result, current limitations of STB hardware and IPG software applications impose significant development challenges that impede the efficient roll out of new, high-revenue generating subscriber services.

However, judicious application of AI technologies, developed over the last 40 years, significantly enhance the range and quality of services that can be implemented via STB applications, and at a fraction of the cost of conventional client-server approaches.

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