Creating Complex Applications Via Self-Adapting Autonomous Agents in an Intelligent System Framework

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***Abstract*— In this paper, we present a process, developed over years of practical commercial use, where applications accomplishing a wide variety of complex tasks are created from a common framework, through the use, recombination and iterative refinement of autonomous agents in a Multi-Agent Intelligent System. Driven by a need to solve real-world problems, our focus is to make businesses run more efficiently in an increasingly complex world of systems and software that must work together seamlessly. By listening closely to our customers' problems, we discovered points of commonality, as well as patterns of anomalies related to the flow of data through communication channels and data processing systems, include accounting, inventory, customer relationship management, scheduling systems and many more. We solved their problems through the creation of an Intelligent System, where we defined and implemented software agents that were highly configurable, responsive in real-time and useable in various settings. Autonomous agents adhere to a standard format of three major components: the goal or triggering criteria, the action, and the adaptation response. Agents run within a common Intelligent System framework and agent libraries provide a vast set of component behaviors to build applications from. Agents have one or more of the following component behaviors: sensory aware, geo-position aware, temporally aware, API aware, device aware, and many more. Additionally, there are manager-level agents whose goal is to keep the overall system in balance, through dynamic resource allocation on a system level. To prove the viability of this process, we present a variety of applications representing wide ranging behaviors, many with overlapping agents, created via this approach, all of which are in active commercial use. Finally, we discuss future enhancements toward self-organization, where end users express their requirements declaratively to solve larger business needs, resulting in the automatic instantiation of a solution specific intelligent system.**

Keywords—multi-agent intelligent system; autonomous agent; dynamic processing; application framework; artificial intelligence; automated integration; resource allocation

I. INTRODUCTION

At the intersection between researching new and better ways to create software, with the goal of solving common problems felt by most small businesses in the everyday world, is where we have focused our attention to create software systems to meet the needs of a dynamic environment. The needs of the world grow more demanding, and people expect more, and they demand it more quickly. Companies need new applications faster because technology advances continue to update rapidly. New innovations from the past few years are now commercially available, such as 3D printers for additive manufacture, WI-FI enabled cars with driverless automation options, and the near-term future of Internet of Things (IoT) that will connect even more devices to the Internet, are but a few examples of an exciting and dynamic world of innovation. All the while, there are unmet needs in the older technologies used by small and medium sized business that want to benefit from the current climate of innovation.

Large corporations can consider venturing into the newer innovations, but smaller companies don't need to be restricted, even though they are much more sensitive to disruptions in everyday workflow caused by the introduction of new technologies. Smaller companies deal with the everyday challenges of creating new jobs, making payroll, and staying ahead of the competition. Everyone knows someone in these fields of small and mediums sized business in service industries such as construction, plumbing, house cleaning, roofing, lawn maintenance, security systems, flooring, cleaning vents, etc. These are the services that keep people employed and modern living civilized.

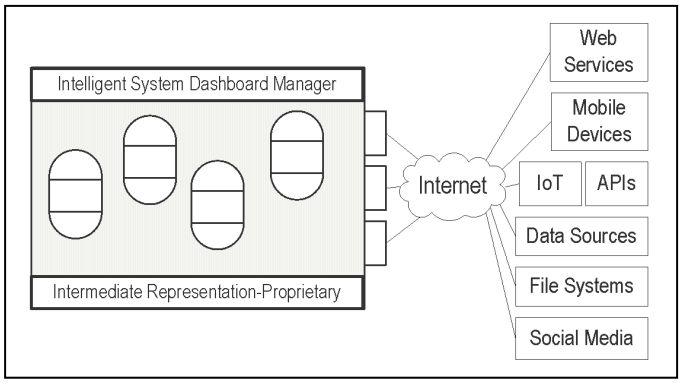

Fig. 1. Intelligent System with Agents

There is an interesting set of problems when dealing with technology challenges for smaller, 'blue collar' businesses as they adapt to the changing world. These businesses were built from processes that work extremely well for them, but as they

grow, they don't have many places to turn to streamline as they adopt newer systems being offered to them. Small businesses have specific ways of doing things that are unique to them and typically have very little overhead to learn new systems, to streamline and innovate. The challenge is that if small businesses don't innovate, they risk losing marketing share.

II. Self-Adapting System

We create applications by defining the application requirements in terms of their goals. Agents from an ever expanding Agent Library are added to a new instance of the Intelligent System, which are then configured according to the overall application goals. Agents have the ability to monitor data bandwidth and respond accordingly by making copies of its process, increasing or decreasing sampling times, or deleting themselves when no longer useful.

Agents are organized into units with common interfaces that can be recombined, and are: Event aware, API aware, Device Aware, Time Aware, Location Aware, Data Aware, Communication Channel Aware.

With an expanding agent library, we can create applications quickly by adding agents that fulfill some of the goals. If a new API or type of record is part of the goal, the development time required to create new agents for feature gaps is low as the agents are all template based on the standard set of interfaces.

A. Self-Adapting and Learning Processes

Self adaptation occurs in several places in this system. Agents have an 'adaptation response' phase where they can adjust settings according to their environment. This is encapsulated and the adaptation is specific to the agent functions. For example, a location aware agent could work with an area of focus that could grow or shrink depending on processing results.

Agents are completely encapsulated and it's up to the IS to bring them together to solve the overall application problem or meet the overall goals of the application. Agents have the ability to learn over time if this is part of its overall goal. For example, a location aware agent could monitor daily GPS enabled bus routes to learn their expected arrival times at stops along each respective route. Once the times were learned, the agent would be able to detect an exception to the pattern and issue alert using a communication aware alert such as sending a text message to people who subscribe to the bus route status that it's been delayed.

B. Autonomous Agents

Agents' functionality is encapsulated by follow a standard template of three main sections:

1) Trigger / Goal

Agents are designed to perform an action in response to a trigger event or goal. The trigger depends on the type of agent and how it's configured.

2) Action

The action can be any type of business logic, connection to any type of API, any type of communication channel connection, etc. Any type of programming activity can become an action. For Data translation agents, the trigger will be configured to determine what type of data is read in and from where (which API, web service, file, device, etc). Data is translated into the proprietary intermediate format. This reduces overall complexity and allows for an architecture of ever expanding library of agents.

3) Adaptation Response

After the trigger has been detected and the action is completed, there is final phase where the agent can make adjustments to its configuration that will cause it to either self-adapt or will cause other agents to run differently (and hopefully enhanced) when a spike in data occurs, agents can self-replicate or adjust how often they respond to potential triggering events.

Likewise with cloning themselves, they can end their execution or slow how often they check for triggering events. A goal of the adaptation response is to best use available resources seeking overall system equilibrium and leveled balance of data being processed.

Each agent is configured based on the goals they seek to accomplish and the actions they perform. The adaptation responses can change the configurable parameters of its, and/or other agents. The adaptation response can provide logging and health/wellness information to the IS dashboard manager. Adaptation responses can also request further resources.

III. Use In Practice – Find Me Safety™ Platform

The Find Me Safety™ Platform is a coordinated set of software components that includes, at its heart, an Intelligent System. The Find Me Safety™ Platform supports a family of safety applications, including: Find Me – Tornado Safety™ , Find Me Safety™ ,Find Me – Earthquake/Tsunami Safety™

This platform simultaneously interacts with various data sources, such as NOAA/NWS used by the agents in the Intelligent System that monitor mobile app usage, user locations, countdown timers, and maintain communication channels to notify by email, text message, phone and push notifications. This application was built by combining pre-existing agents from the Agent Library for notification, event and API agents and implementation time was three months to complete, where using traditional methods would have taken 18 to 36 months to complete.

The commercial world of Information Technology is always changing as companies innovate and stay competitive. By having a system that adapts to a changing world quickly means that user needs are solved quickly. The number of small businesses needing these types of applications to streamline is very large, while their ability to adopt new data practices fairly low, as it is often seen as too disruptive to their daily operations.

This process and framework addresses the needs of small and medium-sized businesses, as they expand their business to adopt newer technologies. By using an Intelligent System with an expanding Agent Library with agents that recombine to perform specific tasks, that are highly configurable and dynamic to their environment, results in reduced costs and complexity.