Humans and Machines in Effective Real-Time Collaborative Systems

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November 2017

VANTIQ

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WHY READ THIS PAPER

There is about to be a discontinuity in how humans and business software applications work together. It is not yet appreciated how collaboration between increasingly powerful applications and humans will offer major advantages and avert problems as we automate the world. This paper presents a case for real-time collaboration between humans and so-called 'machines' —and, why enabling such powerful collaborations must become a priority for enterprises looking to drive their digital businesses transformations.

INTRODUCTION

Every company must use advanced technology to digitize their business to remain competitive. New software applications are being created or contemplated to make this happen. These applications will deploy numerous modern technologies such as the IoT, mobile, AI and external services. They will be situationally aware and make decisions in real-time. They will be far more comprehensive in scope and far more complex in structure—more moving parts—than existing business applications.

Because these applications will control much more of a business, close collaboration with humans will offer significant benefits and will become a requirement in the not too distant future. Software will automate deterministic functions and standardized activities while humans will add experience, intuition, and values to: (1) assure the most appropriate actions are taken (2) intervene when they are not, or (3) take charge when it is not clear enough what to do.

Despite the increasing interest in this topic, there is a dearth of discussion regarding how more complex human-system interactions should evolve. By interactions, we are talking about communication well beyond text, email or chat systems. We are talking about truly sophisticated 'collaborations' in which a software application and a human communicate, each being aware of the context of what is happening, how a situation changes with time, and which choices or recommendations will likely produce the best outcome. Imagine two employees working together to solve a problem, each providing unique expertise, except, one is a software application. This paper presents a foundation for thinking about how collaborations can be designed as a part of the next generation of business applications.

A LITTLE HISTORY

Computer systems have historically performed relatively straightforward and deterministic tasks. They automated existing business functions with software applications such as HRM (Human Resource Management) and CRM (Customer Relationship Management). Productivity gains were achieved but they did not modify business operations in any meaningful way. Since these applications performed straight-forward tasks based on existing business processes, they did not require systems and their users to collaborate in any meaningful new ways.

In the last decade or so we have seen the proliferation of social media in the form of Facebook, Instagram, Slack, LinkedIn and the like. This has allowed for communication to be pervasive but in unstructured ways. Business applications need structure, control, mission-criticalness, auditability and close integration to the software application's logic. These requirements for collaboration in business applications are very different from what social media apps provide.

COLLABORATION EXAMPLES

Companies such as Uber, Amazon, Deere and Tesla are creating new business models using software as an enabler. They take maximum advantage of real-time human-machine collaboration and will increase the usage over time, often in unforeseen ways. Think of:

- Links in a supply chain being managed by humans in real-time with the system making recommendations that take specific customer needs into account
- Floor managers in a casino collaborating with an application that combines guidance from ML (Machine Learning) algorithms with data from systems of record to create special offers for high-rollers to keep them engaged
- Amazon drones delivering something to an Uber vehicle in transit and the car only has to slow down or pull over as the package is delivered
- Drones and robots collaborating with firemen to put out a fire
- After an earthquake at a construction site, the systems and the operations personnel collaborate to make numerous critical decisions

Faster response by humans is critical in many situations. Getting doctors, nurses, firemen, and police involved quicker with better situational awareness can save lives. As an example, a study in India indicated that 40% of children after open heart surgery died with the primary reason being that it took doctors on average 90 minutes to get to a child in distress because of ineffective communication. In rugged environments such as offshore oil rigs or underground mines, the benefits of quick action when problems occur are evident.

VANTIQ ADDRESSES THE CHALLENGES

Integrating situationally aware software with decision-capable humans will happen because the benefits are so great. But, creating sophisticated collaborations between humans and machines is very difficult. A Netflix or Uber, each with hundreds or thousands of very talented software professionals can do it over long-enough periods of time.

To address this challenge in a more timely manner with fewer resources, higher levels of abstraction are needed. Throughout the history of the software industry, abstractions have been created to make things easier (e.g., high level languages, visual design tools, relational databases, virtualization). New abstractions are needed to enable collaborations to be easily created.

In 2017, VANTIQ added advanced collaboration facilities to its platform. VANTIQ's core product is a high-productivity platform for building real-time and event-driven business applications. VANTIQ enables scalable and resilient applications to be rapidly created, easily deployed throughout a highy-distributed environment, and then effectively updated and managed.

The latest release of VANTIQ includes collaboration primitives, called collaboration patterns, as seamless components. Collaborations are created with the visual design tool called Modelo. They have all the mission-critical capabilities VANTIQ provides. After initial deployment, VANTIQ collaborations can be easily modified in Modelo as the system requirements change and implemented with no downtime. Within a VANTIQ application, powerful collaborations can be initiated at any time.

WHAT ABOUT AI?

As with any new technology direction, there are skeptics who do not believe it is real. This was true with the PC, the Cloud, and even the Internet. So, what are the possible arguments against collaborative systems? The foremost is that we will automate the world and humans will exist on the sidelines. This would require general Artificial Intelligence (AI) to evolve so that machines will be massively intelligent in human-like ways. Others, pessimistically believe that machines will have unforeseen or emergent behaviors that can threaten our very existence.

These extremes are highly unlikely within timeframes that concern enterprises today. Systems and humans will (and must) complement each other. This is the natural evolution of human-machine interfaces (e.g., Dashboard *mash-ups*, SCADA systems, or HMIs). It requires a shift in thinking in how humans and computer systems interact.

Today, the most common ways humans interact with computer systems are through automated notifications, emails, or phone calls. The user interfaces can be user friendly, but meaningful cooperation between humans and computer systems is rare except in the most controlled situations. For example, Cobots - systems in which humans and robots work together - extend the capabilities of humans. The da Vinci robotics system used by surgeons to perform operations such as a gallbladder removal is an example. The robot acts as an extension of the surgeon's senses with 3D vision and haptic feedback. Such tightly controlled situations do significantly extend human abilities, but, there is no *true* collaboration as the human drives everything. In this *first generation* of collaborations, the machines serve as slave devices.

Enterprises are attempting to re-invent themselves and turn into a digital business. This digitalization operates in real-time, taking in events and data streams as they are generated. Knowing when a good customer needs help, a delivery will not occur in time, or there is a high likelihood of a compressor failure within hours, can improve business efficiency and customer satisfaction. In a collaborative model, computers and humans will each do what they do best

with the resulting system being more effective by combining the efforts of both into a seamless whole. In these systems, safety, efficacy, and security can be enhanced. The complexity (and importance) of enabling powerful human-machines collaborations will only increase as machines get smarter and are able to become true partners in a collaboration.

COLLABORATION VS. WORKFLOW

Some business people think of their existing workflow systems as defining collaborations. However, such systems are not collaborative, but prescriptive with the workflow system sequencing all user activities. Essentially, the workflow system tells the user what to do at each step in the process treating the user as just another machine. This is not *true* collaboration.

VANTIQ's collaboration capabilities allow both the system and the user to act in a manner that best fits the current situation, informed by available data about events happening in real-time. The user may have deeper knowledge than the system of the next step in the process and initiates the desired action; the system, through its real-time sensors, observes the change via streams of real-time 'event' data and responds with its next set of recommended actions. The user may elect to take one of the recommendations or, using their experience, intuition and a more comprehensive understanding of the overall context, elect to take a different course of action. In such a highly flexible environment, both the user and the system adapt to each other, rather than the system driving (workflow) or the user driving with the system blindly following.

RIDE SHARING APP AS AN EXAMPLE

To illustrate the types of collaborative applications VANTIQ can build, an application like Uber or Lyft serves as an example. The human-to-system interaction could be developed using VANTIQ in just days and rapidly scale up to support billions of rides per year. Figure 1 below represents the collaborative portion of such a ride sharing application. The component in VANTIQ that creates the visual model of the application is called Modelo.

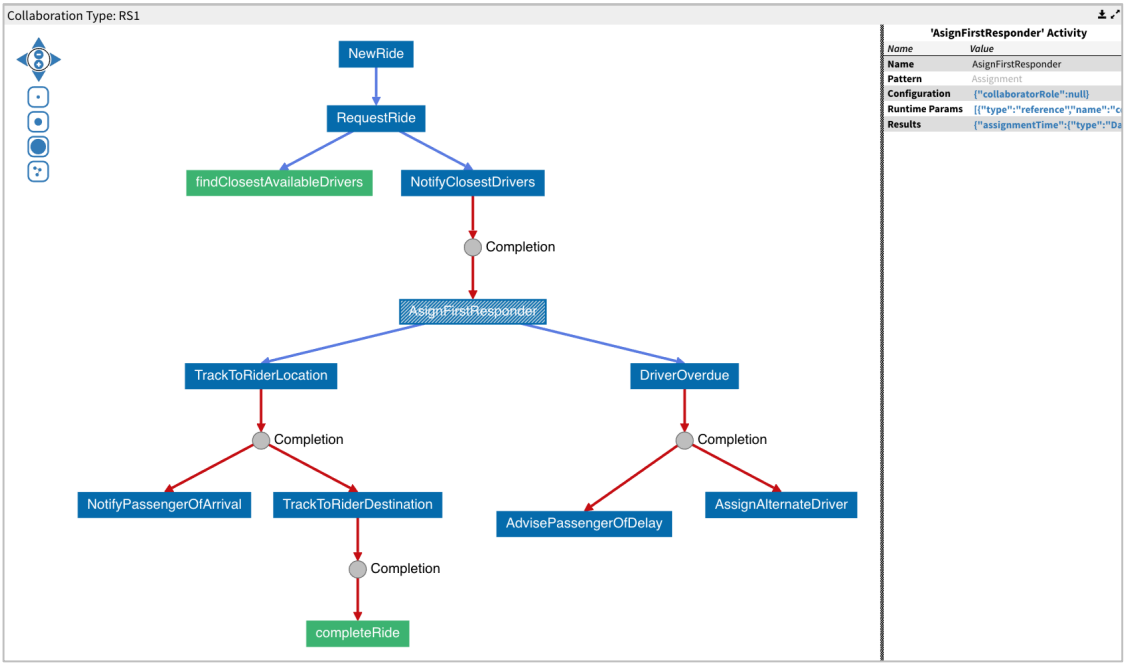

Figure 1 – Rideshare collaboration designed in the VANTIQ Modelo visual design tool.

A passenger notifies the system to request a ride. The system sends a request to all drivers within a specified distance of the passenger. A driver then manually accepts the ride. Once the driver accepts the ride, the system will automatically prevent other drivers from doing the same. The system will track the driver to the passenger's location while establishing an escalation to be triggered if the driver does not arrive within a specified time. If this happens, the user is notified of the delay and another driver is assigned. When the driver arrives, the passenger is notified and the driver and passenger are tracked to the passenger's destination at which time the ride is completed and the collaboration is closed with the appropriate systems of record being updated.

Using VANTIQ's collaboration patterns and rules, numerous other interactions could be added such as:

- If the passenger leaves something in the car, the application, the driver and the passenger can all collaborate with recommended actions based on location, importance, and additional cost.
- If automatic location tracking fails (e.g., GPS is blocked in a large covered area), collaboration with alternative systems (i.e., automatic text messages) or appropriate people can be initiated.

- If the passenger wants to add another activity such as purchasing flowers on the way, additional collaborations can be generated with multiple systems and people communicating.

VANTIQ supports the design of this type of real-time collaboration using Modelo. Modelo collaboration diagrams are not flows since, in a true collaborative fashion, actions may be taken in any order that make sense at any given time as situations change in real time and events continue to stream in. Additionally, many activities may be progressing in parallel. These diagrams represent the set of current activity possibilities from which the system and the users choose the most relevant for any given situation.

VANTIQ COLLABRATION PATTERNS

The VANTIQ collaboration patterns include:

- Automatic integration between *Situations* (state of an application at a point in time, derived from one or more data streams as defined within VANTIQ) and Collaborations to seamlessly provide collaborative services for situations recognized by VANTIQ's real-time analytics.
- Powerful recommendations of which collaborators are best fit to carry out the activities defined within a collaboration and negotiate acceptance of their assignments.
- Guidance for collaborators assisting them in carrying out their assigned activities.
- Escalations for raising the priority and visibility of situations that cannot be resolved by the initial collaborative activities.
- Location tracking of assets and collaborators.
- Messaging services that allow the system to act as an intelligent assistant augmenting conversations in a context specific fashion.
- Natural language processing (NLP) that allows humans to collaborate with machines in a more natural, conversational manner
- Real-time notifications that trigger integration of new collaborators into an ongoing collaboration which can include traditional presentation and data acquisition services as well as an emphasis on multimedia data collection.

These patterns can be declaratively assembled into rich collaborations involving multiple users to optimize the results. Appendix A describes these patterns in more detail.

REPAIR APP AS AN EXAMPLE

A failed machine will serve as another example. The precise nature of the machine is not relevant. The basic use case is as follows:

- A machine fails.
- A tech specialist is assigned to diagnose and repair the machine.
- The tech specialist travels to the site of the failed machine, runs some diagnostics, determines the exact problem and repairs it.
- The machine is brought back online and production resumes.
- If the machine is not repaired in a timely fashion, the problem is escalated to a supervisor who assigns a senior technician to diagnose and repair the failed machine.

This use case is simple but an optimal solution requires extensive collaboration between the real-time application and the collaborators such as the tech specialist, the senior tech specialist, other available technical resources, and the supervisor. Figure 2 depicts the VANTIQ Modelo design tool which graphically displays the activities in the collaboration as described next. Translating the use case into a high-level view of the system charged with implementing the detection and repair of the machine might result in the following activities:

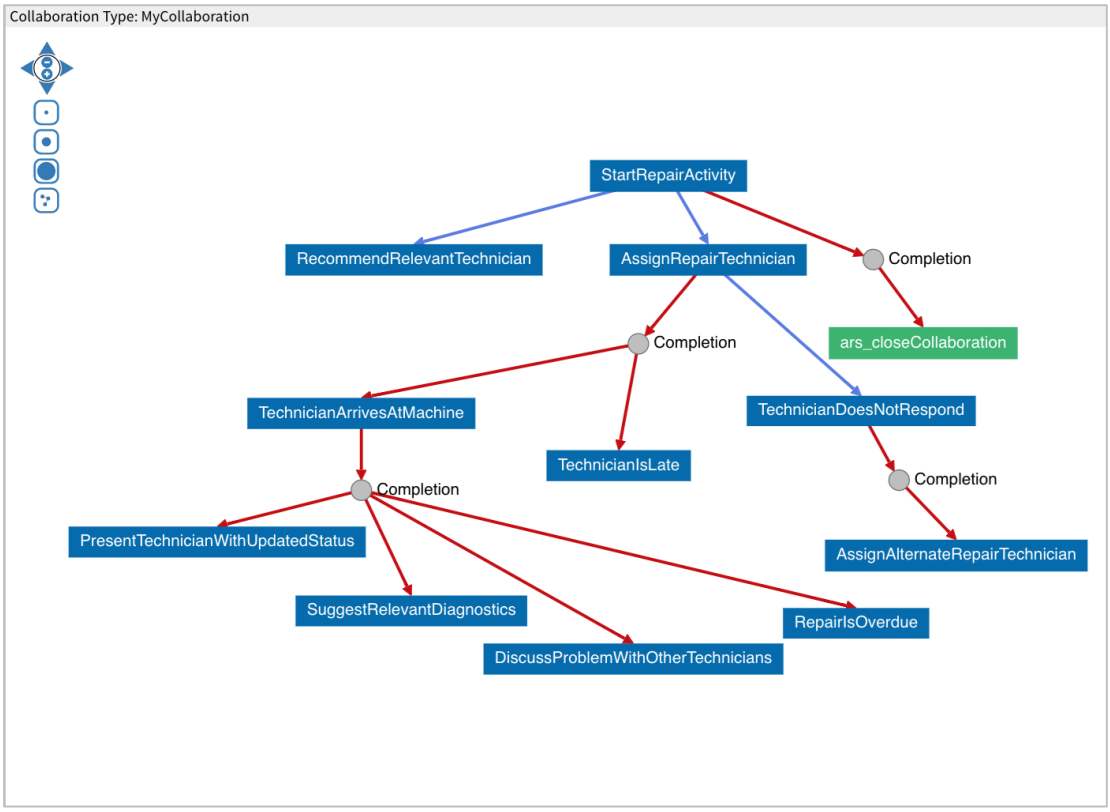

Figure 2 - Repair collaboration designed in the VANTIQ Modelo visual design tool.

The real-time analytics subsystem identifies the fact that a machine has failed and creates a *failed machine* situation. The *failed machine* situation initiates a *repair machine* collaboration binding the collaboration to the *failed machine* situation. The collaboration evaluates the current state of the machine to determine the most likely problems and selects a technical specialist to service the machine. The selection is based on the most likely problems, the skills of the tech specialists, their availability and their location (variables that are constantly changing). The technical specialist acknowledges the assignment, triggering additional background activities. The specialist travels to the failed machine. Location tracking is started so that up to the second status and recommendations can be supplied to the tech when the tech arrives at the failed machine. An escalation activity is started such that if the machine is not back online in a timely fashion, a supervisor is notified and may assign additional resources.

The tech arrives at the failed machine, is presented with updated status information and recommended diagnostic procedures. The tech proceeds to diagnose the problem with the system offering updated suggestions along the way as the state of the machine being repaired changes in real-time.

The tech may correspond with other techs to gain the benefit of their experience with similar problems. The system may augment this conversation with more recent status information as well as new suggestions based on the content of the conversation. The tech repairs the machine. The machine is returned to an operational state recognized by the system which, in turn, closes the collaboration.

Several exceptional conditions may occur during the execution of this collaboration:

- The tech fails to acknowledge the assignment in a timely fashion.
- The tech does not arrive at the machine in a timely fashion.
- The tech solicits more help from the system and other users.
- The repair task is not completed in a timely fashion.
- The machine does not come back online in a timely fashion.

These conditions can all be handled as escalations that assign additional resources to the collaboration either automatically or in collaboration with one or more supervisors.

Building such a collaboration in traditional tools would be a very time consuming and expensive programming task. With VANTIQ this collaboration can be declaratively defined with very little effort using the VANTIQ Modelo visual design tool. Once the activities have been assembled, the developer provides any specialized semantics unique to this system as simple declarations or more expressive scripts. The entire collaboration can be constructed in an iterative and dynamic fashion inspecting the behavior of the collaboration in real-time as each change is made. In this manner, the developers and the end users can jointly define the application.

SUMMARY

While there may be specific areas where total automation is possible, the combination of computers and humans working together collaboratively will increase operational efficiency and enable new business opportunities. Machines will do what they do best such as solve deterministic problems and control standardized activities in real-time. Humans will do what they do best, high-level analysis of situations and decision making based on experience, intuition and values. Systems that are developed with both of these capabilities in mind will offer significant advantage. The VANTIQ collaboration system was designed to enable such systems to be rapidly developed and easily evolved with far less risk.

With experience, collaborations will become increasingly more powerful and more natural. VANTIQ is developing new techniques and incorporating more technologies to assist in this natural evolution. Collaborations will have a major impact in how organizations operate.

APPENDIX A: VANTIQ PATTERNS EXPLAINED

VANTIQ collaborations are easy to build because they are assembled from high level activity patterns optimized for numerous collaboration tasks. Without these abstractions, significant amounts of low level system code would be required to be programmed. For example, assigning a user to a role in a collaboration involves numerous steps such as selecting candidate users using *fitness* algorithms, notifying them, collecting responses, selecting one of the candidates and notifying and freeing up the others. This complete process is encapsulated in the *assignment* pattern.

Another example is location tracking in which the collaboration needs to know when the user arrives at a designated location, but does not need to be involved in the details. The *location tracking* activity is triggered and subsequently monitors the user's location until the user reaches the specified destination. An event is then raised and the collaboration can trigger any activities that are dependent on the user's arrival.

In the first release of the VANTIQ Collaboration facility, the supported patterns include:

- Assignment
- Conversation
- Escalation
- Location Tracking
- Notification
- Recommendation
- Guidance
- Natural Language Communication
- Approvals

Assignment

The assignment activity pattern assigns entities, typically users, responsibility to execute some task. For example, a tech specialist may be assigned to repair a failed machine. The capability is general as it could be used to assign any entity types to any kinds of tasks. For example, we might assign cars to renters in a rental car scenario. Thinking of the cars as entities and the tasks as transporting

renters allows us to think in terms of cars assigned to renters rather than renters assigned to cars.

The assignment activity supports three types of assignments:

- auto - the assignment is made automatically by the system.
- manual - the system proposes a set of potential assignments and a designated user selects the actual assignment from the list. This corresponds to scenarios in which a supervisor chooses assignments.
- self - the assignments are advertised to all potential assigned entities and the first one to accept the assignment is assigned. This corresponds to a classic situation where a job is advertised and then assigned to the first taker.

Conversation

Conversation among collaborators must be enabled and augmented as necessary. The conversation may use either an existing channel or a new channel. The collaborator is presented with the dialogs necessary to participate in the conversation. The conversation may be accessed via the VANTIQ Mobile Client or one of the popular messaging systems such as Slack or Microsoft Teams.

Conversations are augmented by a set of conditions and actions that are applied to the messages of the conversation as they are inspected by the collaborative activity. This gives the system the opportunity to inject additional messages into the stream to advise the conversation participants of additional status information or suggestions known to the system but likely unknown to the participants.

Escalation

Escalation sets an expiration time and a condition to satisfy. If the condition is not satisfied before the expiration time, the escalation is activated and proceeds to select alternate or additional resources to apply to the situation.

Location Tracking

A common activity pattern is tracking users that are bound for a known destination established by a collaboration. For example, a tech specialist has been assigned to fix a machine and is en route to the machine's location. The overall repair collaboration would like to assign the user the repair task and then ignore the user until they arrive at the machine's location. Location tracking provides exactly such functionality.

Notification

The Notification activity pattern presents a notification to the user. Optionally, it may request acknowledgements from the user or drive other synchronous behavior when the collaborator responds to the notification.

Recommendation

Recommendation produces a list of relevance ordered recommendations from an inventory of candidate recommendations based on their relevance when matched against a pattern describing the desired attributes of the recommendation.

The resulting recommendations are presented to the user.
Recommendations are selected from an Inventory of available recommendations using either a system defined default scoring algorithm or a user supplied scoring algorithm to find the most relevant recommendations.

Guidance

Guidance represents collaborations in which the real-time system provides recommendations and then guides the user through the process of applying the recommendations to a situation. A classic example is a diagnostics tree where the user starts at the top of the tree applying some diagnostic procedure that returns a result. Based on the result, the tree determines the next diagnostic to apply. This process continues until a leaf of the diagnostic tree is reached. At that point, the problem should be understood and a response can be applied. Guidance is more flexible than a traditional diagnostic tree. In guidance, the

collaborator is presented with options. The collaborator executes an option which returns new data to the system. The system then constructs a new set of diagnostic options and presents these to the collaborator. The collaborator then executes one of the options and the process continues.

Each guidance activity may simply request that some action be taken by the user or may solicit input using a specific presentation page for obtaining the data. The page is backed by a service that collects the data provided by the user and augments the current state of the entity for which guidance is being provided.

Natural Language Communication

In conjunction with conversations, there are many situations in which the user would like to solicit additional information from the real-time system. The natural language communication activity would allow the user to pose questions to the system in the context of an ongoing conversation. The system would then parse the request, assemble a response and format it appropriately for delivery over the conversation channel.

Such processing gives the user even more freedom in the manner with which they collaborate with the real-time system since the universe of possible user requests do not have to be pre-configured into the system.

Approvals

Approvals will assure that any chosen system changes receive the appropriate approval from one or move individuals or other applications. The system will provide various approval options as a function of the authority of the individuals involved.