USER-CENTRIC AND CONTEXT-AWARE ABC&S

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Abstract*: The evolving Always Best Connected and best Served (ABC&S) communication paradigm is addressed in this paper. The goal is to propose aspects of a novel vision together with the consequential strategic requirements and potential solutions for system architectural development. Subjective and objective aspects of the ABC&S concept from the viewpoints of the various stakeholders – mobile users, access network providers (ANPs), mobile service providers (xSPs), and mobile device manufacturers – are delved into. As primarily ABC&S is an end-user's issue this perspective is given priority. The importance of context awareness is highlighted and the main context types are identified. An illustrative ABC&S example is presented along with corresponding IT solutions.*

Keywords*: Always Best Connected and best Served (ABC&S), user centricity, context awareness, mobile app, cloud-based system, service recommendations, Ubiquitous Consumer Wireless World (UCWW).*

ACM Classification Keywords*: H.3.4 Systems and Software – User profiles and alert services, C.2.1 Network Architecture and Design – Wireless communication, D.2.2 Design Tools and Techniques – User interfaces, H.1.2 User/Machine Systems – Human information processing.*

1. Introduction

The "Always Best Connected" (ABC) path of the evolution of the future communications world was proposed in 2003 [Gustafsson, 2003], [O'Droma, 2003]. The ABC concept was later extended to an "Always Best Connected and best Served" (ABC&S) paradigm [O'Droma, 2006], [Ganchev, 2007]. As part of the ABC&S functionality, in general, users evaluate their options in relation to the provision of desired mobile services through access networks available to them, and make decisions on which (best) access network to use, under what conditions and for which particular service instance.

The ABC&S concept may be considered as the vision where logical telecommunication connections, needed for services being used by mobile users, are realized in a way that would be regarded as 'best' by these users [O'Droma, 2006]. What is 'best' varies widely according to the viewpoint of the stakeholders involved, the user's location, the network environment enveloping the user, the service instances being provided and the time the service is being accessed (time of day, day of week, etc.).

With this kind of general descriptive definition, what ABC&S actually would be at any time, in any place, for any user, mobile service provider (xSP), and access network provider (ANP) will vary and will evolve radically as the full gambit of future wireless networks themselves evolve.

In future wireless networks, the ABC&S vision should also include the capability of flexible management of the all-important quality of service (QoS) requirements ranging over all protocol layers [O'Droma, 2004]. In environments containing multiple wireless (and fixed) networks, this vision includes open access to all of these networks, under certain conditions, and the ability to create, and update, a mix and match of desired service instances based on acceptable price/performance ratios – all responding to requirements set down by users in their profiles. Whether in a mobile or fixed context, it also includes a capacity to advertise, discover and learn about new networks (and services), new network- and service options and price/performance offerings, and dynamically change access, without losing service session, in accordance with user preferences, or ANP's, or xSP's obligations to meet per-service or per-connection service level agreements (SLA), or service dependent xSP-desired QoS performance. Largely the above is coming at an ABC&S definition from a user's viewpoint. There are other viewpoints – e.g. the mobile service providers', the access network providers' and the mobile device manufacturers' viewpoints, presented in the next section.

In many ways the evolution of mobile communications envisages a stage being reached where the competition among ANPs may be a consideration for each user call/session [O'Droma, 2004]. For example, whenever a phone call is to be made, if the user is within the footprint of several access networks, then clearly s/he would like, in a painless user-friendly way, to choose the network which currently offers the 'best' or most acceptable price/performance ratio for the service being sought. Important also to the user is the need to control the billing options available at any time. This presents a user requirement for a different type of approach to the traditional authentication, authorization and accounting (AAA) structure, as it mitigates against a user's being tied (i.e. as a subscriber) to one ANP – the home access network provider. It may facilitate the user better for the AAA functionality to be mediated by a third party (or parties) [McEvoy, 2005], [Tairov, 2011]. For instance for the traditional service of making a phone call, a user might want different calls to go through different ANPs (3G, 4G, Wi-Fi, Wi-MAX), being selected based on the particular callee, the day of the week, the time of the day, and other user profile's characteristics such as the user role – professional, personal, etc. To do this, mobile devices could have a mobile ABC&S application installed, through which all outgoing phone calls could be easily made. This option is presented in detail in Section 4.

In some cases the user may prefer not 'the best' connection (with best cost/performance ratio) for a given service, but another connection not so expensive and providing satisfactory QoS (for this user in their present or specified role), [O'Droma, 2004]. For this purpose the cost/performance ratio must be

present in suitable measures understandable by the user, e.g. if s/he chooses not 'the best' connection, the user should know how much cheaper it is and what the likely corresponding drop of performance/QoS is.

In the case of using a multi-access device and if the user wants to use two or more services simultaneously (e.g. speaking on the phone and at the same time downloading and reading e-mails with attachments, and also browsing the web) and if s/he is within an environment of overlapping footprints of multi-access wireless networks in the current location, then the user's mobile device may propose using different connections via different ANPs – sorted in descending order according to their cost/performance ratio – for different services, e.g. 4G for a business-type phone conversation and Wi-Fi for e-mail downloading and web browsing [O'Droma, 2004].

As indicated in [O'Droma, 2004], a real drive towards an open ABC&S paradigm has the potential to gradually restructure the existing subscriber-based and network-centric business realization of mobile communications, transforming it into a consumer-centric one. In this, it raises important challenges for existing ANPs and opens new opportunities for new ANPs, aiming to fill niche markets. For the latter it would mean the possibility of ease of entry and of having dynamic (and even casual) consumerist-like relationships with users, i.e. offering and providing services without any prior business relationship and subscription with them, which is realizable through utilization of a 3P-AAA mechanism [McEvoy, 2005], [Tairov, 2011].

For the mobile user the experience of ABC&S communications services should preferable move towards having consumerist-type characteristics where, for instance, through user-friendly interfaces ABC&S decisions are user-driven and user-executed. The most advanced ABC&S scenarios should enable users to move seamlessly between different (wireless) access networks according to their own criteria, e.g. on the basis of a comparison of the price/performance profiles of the networks, while maintaining active/on-going service sessions, i.e. without needing to reinitiate a session, or restart an application. The user-centric and user-driven ABC&S paradigm realization leads to a ubiquitous consumer wireless world (UCWW) communication environment [O'Droma, 2007], [O'Droma, 2010], where connectivity is available anywhere-anytime-anyhow, mobile services are rapidly deployed on-demand, customized to the user's needs, and adapted to the current context in the best possible way independent of the user's movement across heterogeneous access networks. This vision requires unprecedented levels of autonomy, service adaptability, and network element integration at all levels including device equipment, access networks, and mobile services, [O'Droma, 2004].

Most ABC&S decisions, and probably the easiest from an implementation viewpoint, will be made by the user on the basis of criteria many of which will be set down in multidimensional user-, device-,

network-, and service profiles [O'Droma, 2004]. The range and sophistication of such profiles will grow with time in parallel with the growth in the range of device, network and service access options and will consist of complex sets or arrays of competing parameters. How this may be managed in a dynamic adaptable way is not a small challenge. An important research and development (R&D) goal here is the finding of solutions for automation of the entire process of advertisement, discovery, request, association, configuration and use of access networks and mobile services so that the user will not only be served anywhere-anytime-anyhow but also always be best served.

In this paper, the focus is on the ABC&S user centricity and context awareness. The goal of the former is to place wide-ranging freedom and control in the user's hands as regards access networks' and mobile services' choices, based on personal ABC&S criteria such as price/performance ratio matched to the user profile. The goal of the latter is to take into account the current context (user-, network-, service context) in order to make informative ABC&S decisions.

The rest of the paper is organized as follows. Section 2 presents the ABC&S viewpoints of the main stakeholders. Section 3 deals with ABC&S related context. Section 4 describes an illustrative ABC&S example along with corresponding IT solutions. Finally, section 5 concludes the paper and presents future directions for research.

2. ABC&S viewpoints

ABC&S encompasses a vision, which may be defined differently by different stakeholders as outlined in [O'Droma, 2006]. Interpretations and viewpoints vary as a function of the 'interest' of the stakeholder. The definition of criteria for 'better' and 'best' consists of objective and subjective aspects. Normally not only will the categories of stakeholders such as users, ANPs, xSPs and mobile device manufacturers represent broad classes of expectations and requirements of what ABC&S is, but there will also be a wide range of divergent viewpoints within each category related to such matters as socio-politico-economic and regulatory environments, user population densities, service specialization, and geographic/territorial environments [O'Droma, 2006].

In so far as ABC&S has been considered, it has been in the contexts, where the service choice is usually being made by the user according to the perceived cost/performance ratio. However in general, as the ABC&S environment evolves, the user may not be the sole decision maker. ANPs and xSPs also have an interest, more or less keen depending on the circumstances. Besides the cost issue, other items of performance for consideration by all these interested parties include network-related QoS criteria (e.g. bandwidth, jitter, delay, packet loss, network congestion level, etc.), security requirements,

subscriber/user loyalty, service performance history (e.g. response time, reliability, etc.), service provider↔user cost sharing model, etc. [O'Droma, 2004].

A good overview of different ABC&S viewpoints is provided in [O'Droma, 2006] and is summarized in Table 1.

With ABC&S decision-making process being user-driven and/or xSP-driven, competition within and among ANPs should lead to a suitably wide variety of bearer service products with appropriate price/performance configurations [O'Droma, 2004]. Internally for ANP, defining and adapting these price/performance configurations, and keeping users informed about the latest offerings will be a challenging exercise.

Table 1. A summary of the ABC&S viewpoints of the main stakeholders.

	Access Network Providers (ANPs)	**Mobile Users**	**Mobile Service Providers (xSPs)**	**Mobile Device Manufacturers**
Type of control	Centralized with most control being in their hands	Decentralized	Decentralized but supported by ANPs	Centralized or decentralized
Scope	Mostly within their domain only	Global	Global	Global
Driven by whom?	ANPs	Users (and perhaps in cooperation with xSPs)	xSPs in cooperation with users	ANPs, or users, or xSPs.
Goal	More bandwidth, improved range and quality of coverage, attractive tariff plans.	Open consumerist-type price/performance service offering with comprehensive service access	Flexibility in development and deployment of services through third-party networks via open interfaces, attractive pricing mechanisms.	Intuitive GUIs, wide range of network interfaces, greater device reconfigurability options.

3. ABC&S related context

The ABC&S decisions depend greatly on the current context. Besides the context that relates to the mobile *services* available on offer (i.e. the category, type, scope and attributes of the service, the request time, the application initiating the request, the current QoS/QoE index of the service component, price, etc.), the context data may relate to the *user* (e.g., the user location, local time, weather, environmental state, current battery charge and other operational characteristics of the user's mobile device, the user preferences, type of activity, intentions, engagements, social interests, the upper bound on the price and the lower bound on QoS accepted by the user for each particular service, privacy and security requirements, etc.), and/or relate to the constraints of the wireless access *network* currently utilized by the user (e.g., the communication channel state information (CSI), network congestion level, the current data usage pattern, the current QoS/QoE index, the cost of using the network, pricing scheme, etc.). Then determining the 'best' service instance at any moment for a particular user is based on a set of context parameter values, categorized in three groups – user-related *(u)*, service-related *(s)*, and (access) network-related *(n)*, forming a 3D *(u,s,n)* context space, as illustrated in Figure 1.

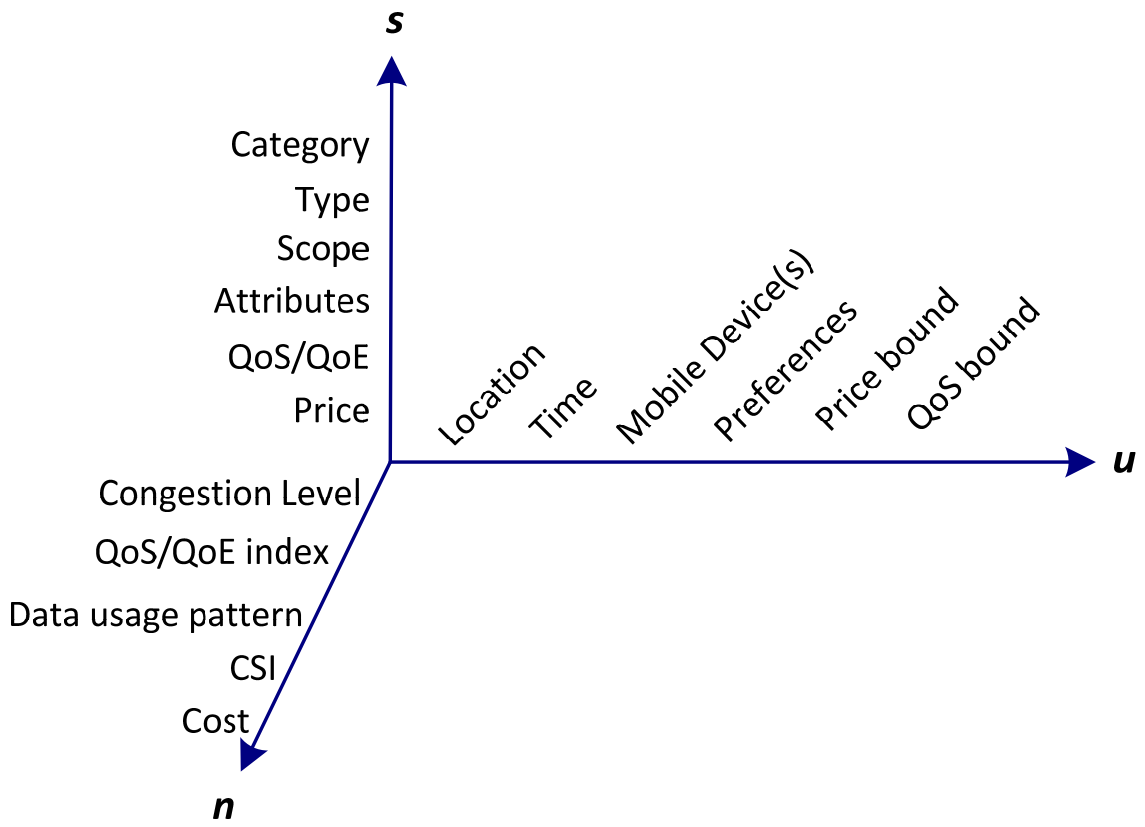

Figure 1. The 3D context space.

The concept of context allows making smart decisions based on mining of data, e.g. stored in cloud repositories. [Ganchev, 2013] proposes the context to include both the data sensed in the environment (as in a typical context-aware system), and the history of the user and the collective history of users who have acted in a similar environment. This constitutes a novel approach in providing context-aware services with elements of community-based personalized information retrieval (PIR), applied to mobile network environments.

4. User-centric ABC&S example

Figure 2 illustrates the user-centric ABC&S concept on the basis of an outgoing call connection service. It shows an example of user A calling user B in the best (i.e. cheapest) possible way. This, of course, will largely depend on the current location of both users (the assumption is that the caller is always aware of the callee's current location). The simplest solution for the caller is to check manually his/her records about the current location of the callee just before calling him/her. For instance, if both users are currently located in their home country (for simplicity it is assumed that the home country is within the EU and is the same for both users), then user A could initiate a call from his/her mobile device through his/her home cellular network to the mobile device of user B, as this is relatively cheap option these days. Alternatively, user A may seek calling user B by utilizing the cheaper option of the Internet telephony, i.e. using the mobile app of some VoIP provider to initiate the call over a Wi-Fi connection, which however could be either paid or free (the latter seems to be the preferred option for low-budget users). Consider now that the caller, user A, moves to another country. Of course using VoIP over Wi-Fi is the cheapest option again. However, within the EU, the cost of international roaming calls is going down all the time (and currently stands as 23.37c/min to make a call and 6.15c/min to receive a call, when roaming). So this could be an attractive option even for low-budget users who want better quality for their calls. Situation however could be quite different if user A is roaming outside the EU, especially if user B is also currently outside the EU and even in the same country as user A (depending on the country, the roaming cost of the call may go up to several euros per minute in both directions!). Spinning (i.e. buying and using local U/SIM cards) represents one possible solution in this case. Users also have the option of using a VoIP over (free) Wi-Fi, however in doing this they still could miss opportunity of using another VoIP service provider, who supplies better rates in the country, where both users are currently roaming in.

Two possible IT solutions for automatic resolution of this situation are described in the next subsections.

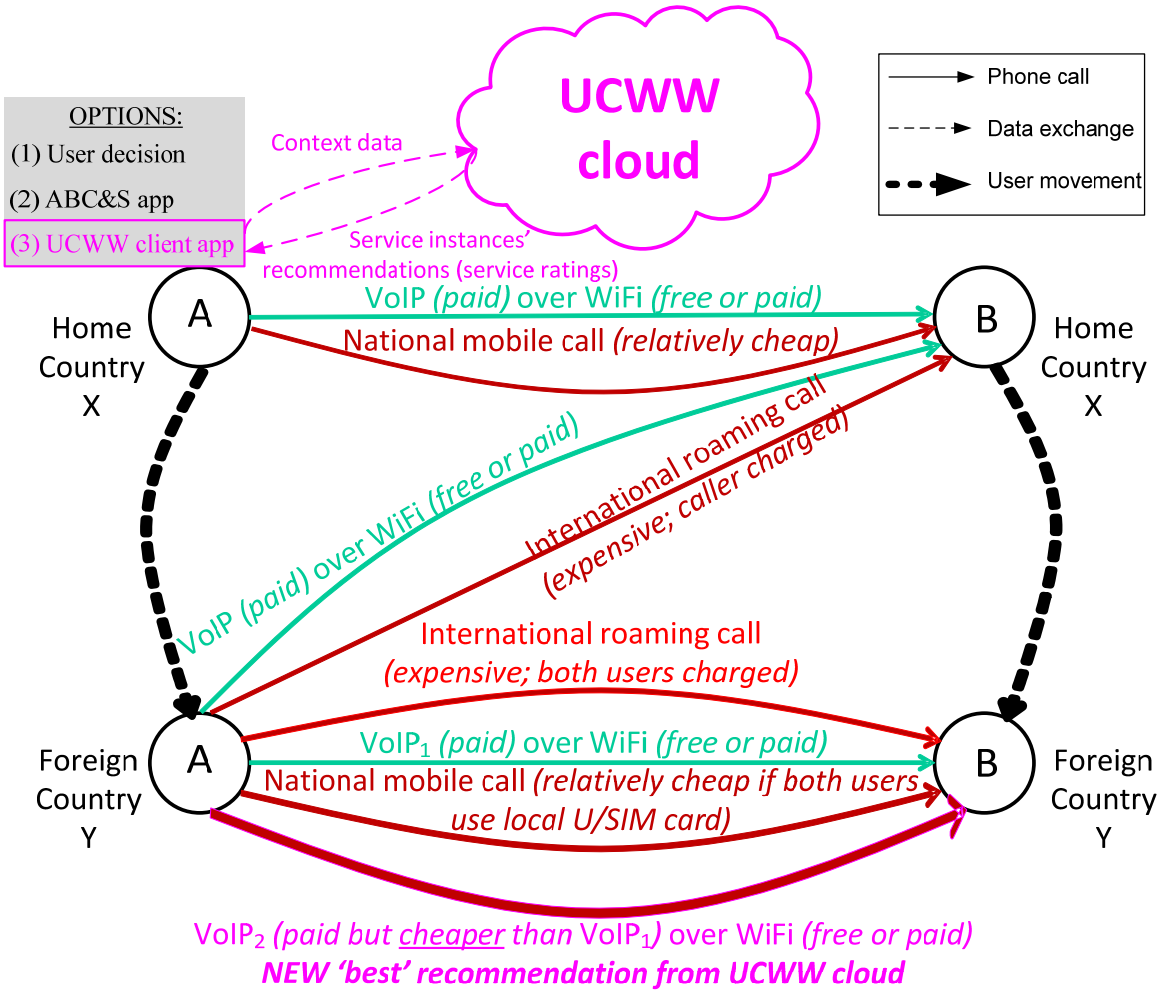

Figure 2. A user-centric ABC&S concept illustration

based on an outgoing call connection service example.

Stand-alone ABC&S mobile app solution

The first IT solution one could imagine is to use a generic intelligent ABC&S mobile application as described in [Ji, 2011]. This application sits on the user's mobile device and operates in the background in supporting the user to be fully aware of all options available to call another user (the ABC&S app finds this information by some means, e.g. by searching on the Internet). The app can thus discover relevant service instances and all the necessary details about their offerings sufficient to make informed ABC&S decisions about using them, including knowing how to associate with the access networks to

obtain these services in the best possible way. This amounts to a significant advance in consumer-centric ABC&S capabilities and services.

Information about the current location of the callee is also collected and stored by the app. So, whenever user A wants to call user B, s/he just needs to select user B (as a callee) from a list provided by the app. The app then will make the call in the best possible way by exploring all available options, one after another, until the call is successfully made.

The entire process is fully transparent and un-intrusive to the user because the ABC&S decisions are made in the background, following default (e.g., lowest price) or preset ABC&S policies and profile settings. This 'full transparent ABC&S' mode means a minimum disruption to the user, and yet it is still consumer-driven ABC&S.

The design and development of such mobile app architecture is described in detail in [Ji, 2011].

Cloud-based solution

The second (and more advanced) IT solution is to use a cloud-based service recommendation system [Ganchev, 2013] as a means for users matching their need to discover the 'best' mobile services, and facilitating, and supporting, the association with them by following a user-driven ABC&S paradigm. A cloud-based UCWW client application [Ganchev, 2015] – associated with such a system – could be used for finding and recommending to users, or even automatically selecting if the user's profile settings are so set, the 'best' mobile services, depending on the current context, including in that decision process the user's personal profile requirements, e.g., for high-quality voice call service (e.g. 3G/4G) when user A needs to talk with her/his boss, but a Wi-Fi/VoIP lower-quality call service selection (where possible) for talking with friends in order to save money. The complex functional requirements of such client application make for a demanding app design, testing, and validation. A possible design solution, realized through a structured composition of three tiers – a mobile application tier, a web tier, and a cloud tier, is presented in [Ganchev, 2014].

As stated in [Ganchev, 2013], the UCWW cloud (c.f. Figure 2) can operate as a middleware of the context-aware service recommendation system. At the lowest layer, the user's mobile device collects context data from the environment, and at the highest layer the UCWW client application makes use of this data. Between them operates the middleware of the system, which could be entirely implemented as cloud services. [Ganchev, 2013] describes in detail the flow of context data between a mobile device and the UCWW cloud as well as the mechanism of sending requests and receiving responses from the

decision support subsystem, i.e. providing ratings (ranking) of the service providers available for a particular type of service requested by the user.

The main goal here is to design an efficient context-aware middleware for the UCWW cloud by having most of its functions offered as cloud services and the rest running locally on the mobile device. This process requires taking into account a number of aspects [Ganchev, 2013]:

- On the back-end, the UCWW cloud must facilitate the storage of data harvested via mobile devices, and based on the analysis of this data, offer predictions as to the applicability and ABC&S suitability of services to particular users. Over time the data collected relating to particular users can give an accurate view of particular cohorts, based on common interests, repetitive access of particular services, etc. By monitoring this information, the system then can accurately predict the types of services most applicable to individuals, and in turn, recommend these to them.
- Efficient heuristic algorithms must be utilized to facilitate service predictions locally on the mobile devices or as part of the UCWW cloud as an alternative to mining the stored data.
- Within the mobile devices, an effective functional GUI design must be facilitated, with the necessary intelligence to harvest the requisite information to facilitate service predictions. With this in mind, different mobile platforms must be targeted, particularly in the case of the smartphones market, where Android-based devices, iPhones, Windows phones etc. each have a market share.

5. Conclusion

In considering the evolution of a truly Always Best Connected and best Served (ABC&S) enabled wireless communications world, this paper addresses the subjective and objective nature of the ABC&S concept from the viewpoints of the key stakeholders, i.e. the mobile users, access network providers, mobile service providers, and mobile device manufacturers. In particular, it has been shown that the ABC&S definitions and implementations are largely driven by the user requirements, which leads to a user-centric ABC&S realization. This thinking contrasts with supporting ABC&S development through centralized access-network-provider's management domain as seen by other researchers. A simple example to illustrate this user-centric ABC&S concept, along with corresponding context-related aspects and possible IT solutions, has been provided.

In evolving future wireless world paradigms, the ABC&S concept itself, and the contexts in which it will likely find application, need to be evolved and extended to include some new dimensions, such as adaptive services/applications, open interworking and interoperability of multiple homogeneous and heterogeneous single-access and multi-access wireless networks, reconfigurable devices and network nodes, and operators competition [O'Droma, 2006]. Exploring and defining new ABC&S scenarios, network/service/device environments and techno-business models, implicit in positing ABC&S as a key and integral feature of future generations of wireless communications, necessitates setting down of many new architectural and system design components. These will be the goal of future research.

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