SENTENTIA – Proximate Collaboration and Multicasting with Augmented Identification

L.S. Jayasinghe, P.G. Kalansuriya, T.D. Ranasinghe, L.K. Vithana, and S. Thelijjagoda

Abstract—**The notion of collaboration has always been an essential ingredient of human society. It served as the mortar to the foundations on which civilizations were built. However, with the advent of distance collaboration humans have grown apart. Vis-à-vis communication is nearly extinct and we always overreach to obtain even the simplest of services. Realizing the issues therein, Sententia aims to introduce an alternative approach which backtracks to the roots of human collaboration through the use of cutting-edge technologies such as Artificial Intelligence and Augmented Reality. This approach is taken in conformance with two architectural models which are introduced along with the system. The first, termed Proximate Collaboration, is akin to "reading the minds" of individuals that approach you and discovering if their ideas match yours' or if they possess what you require. The second, termed Proximate Multicasting, maps each individual to a role in the society and offers those strangers around you as potential sources of services. In addition, it conceptualizes a community of humans as an organic network to facilitate quick and reliable information propagation to promote a collective intelligence. Furthermore, the incorporation of Augmented Identification supplements the above models by providing a mobile reality browser which populates an individual's environment with collaborative information.**

Keywords— **Human Collaboration, Natural Language Processing, Augmented Reality, Proximate Collaboration, Proximate Multicasting, Augmented Identification**

I. INTRODUCTION

Broadly defined, any technology that facilitates the unison of two or more humans to cooperate towards a common goal is considered to possess collaborative features [1].The complexity and increasing demands of today's business and social ecosystems have driven the conception and evolution of collaborative technologies on a broad scale. Thus far, the progress made in the domain of human collaboration has exhibited is extensively; yet its effectiveness is debatable.

With the advent of the internet and the technologies therein, humans tend to reach out across vast distances to fulfill even the simplest of needs. This process of distant collaboration has become commonplace in our lives that we do not think to question whether it has grown obsolete. When put under scrutiny, this popular concept yields many inadequacies and shortcomings.

1) **The Response Delay –** a requirement posted online may entail a considerable period of time to gain a response.
2) **Insecurity of Responses -** a collaboration initiative (such as a startup) may never receive a response.
3) **Monetary Costs -** the collaborative process itself may incur additional costs such as courier costs.
4) **Concerns of Authenticity -** participants are inclined to converse vis-à-vis when the stakes are high and failure may jeopardize collaboration.
5) **Available yet Unattainable -** on rare occasions, an existing service may regrettably be unreachable due to the provider's locale.

L.S. Jayasinghe, P.G. Kalansuriya, T.D. Ranasinghe and L.K. Vithana are with the Sri Lanka Institute of Information Technology, Malabe, Sri Lanka.

S. Thelijjagoda is with the Sri Lanka Institute of Information Technology, Malabe, Sri Lanka. (e-mail: samantha.t@sliit.lk)

A careful analysis of these existing issues necessitated an architectural transformation in the current collaboration model. An alternative hypothesis was proposed.

If given the means to discover the intentions of those nearby, preferably through learning their thoughts, individuals would seize that opportunity to collaborate.

This hypothesis is a drastic divergence from the traditional practice of distant collaboration and it presents a simple yet subtly profound notion, "*why do we exert ourselves to great lengths and reach out over vast distances without ascertaining if any individuals right next to us can serve our needs*". This hypothesis and the accompanying notion inspired the fundamental principles behind SENTENTIA.

II. BACKGROUND AND RELATED WORKS

A concrete implementation of the theorized notion required the design of architectural patterns which could mold the hypothesis into a working solution.

A. *Concepts and Architectural Models*

Two architectural models were conceived in adherence to the proposed hypothesis.

1) Proximate Collaboration

This dictates an architectural model involving the tracking of anonymous individuals in one's immediate vicinity in order to realize any productive endeavors in collaboration. Its application is of twofold.

a) Evaluating one's neighbors to determine if they possess matching ideas.

b) Discovering those that are able to provide a service which one requires.

2) Proximate Multicasting

This dictates an architectural model of information dissemination among selected individuals within a predefined boundary. Its application is of twofold.

a) Contacting nearby "strangers" instantaneously to serve a spontaneous requirement.

b) Transforming one's self to a node in an organic network of humans capable of information dissemination and propagation.

The two models exhibit broad-spectrum applicability and their usage may be localized or distributed on a large scale.

B. *System Architecture Overview*

The design was formulated for optimal integration of the proposed architectural models. The architecture exhibits a multi-tiered design where a mobile frontend allows the user to access services of the system en-route while a centralized backend performs the bulk of the business processing. However, certain components, such as those pertaining to location based services, were migrated to the frontend so as to reduce network overhead.

C. *Mobile Frontend Overview*

A generic user is allowed to access the services of proximate collaboration and multicasting through a *faceted* mobile frontend. **Facets** are different perspectives of the same mobile application which expose different services.

Two prominent facets are the Roaming and Multicasting facets which facilitate access to the Proximate Collaboration and Multicasting services respectively. The Augmented facet displays exposes Augmented Identification features and the IM facet facilitates instant messaging between users.

D. *CollaborationInitiation*

This is dependent on the fact that *a thought is no less of a thought when it is spoken or put on paper*. This implies that an individual could relate a thought to the system through textual input. Hence, the Roaming facet allows a user to enter a thought via text and choose the criterion to which subsequent processing should occur. These criteria are detailed below.

i. **Criterion Similar** – where thoughts are coupled based on their semantic relatedness.

ii. **Criterion Opposite** – where thoughts a coupled based on a requirement versus service match discovery.

As a practical example for the first criterion consider two generic thoughts. The first thought being "*I love working on quantum mechanics*" and the second being "*Studying physics is a passion*". Since the semantics of their thoughts are quite similar the two individuals will be alerted instantly when they arrive within close proximity of each other. As an example of the second criterion, consider the thought "*I must buy a car*" and another "*I have to sell my car*". The first is a requirement which is clearly fulfilled by the second and hence each individual will be alerted as the other passes by.

Following a thought submission, the user is free to continue with his daily activities till the **Smart Data Pushing Module** determines that a drastic change in vicinity has occurred. Only then will a request be dispatched to the backend for processing the immediate neighbors 'thoughts.

E. *Proximity Awareness*

This module found on the backend is able to recognize individuals who are in close proximity to a given a user.

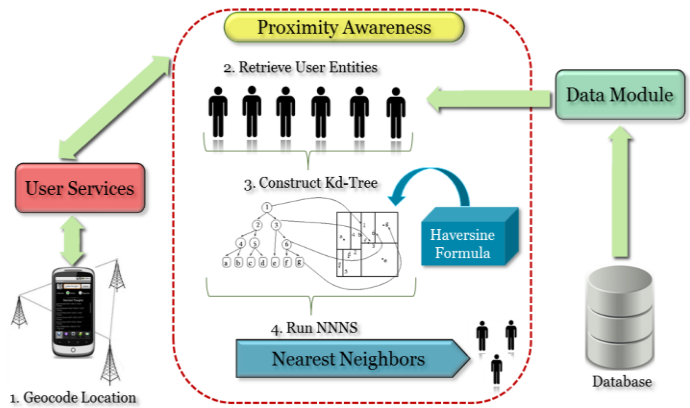

Fig.1. - Proximity Awareness Overview

In addition, it acts as the gateway for collaboration and multicast requests since the proximity information is an essential requirement of either request.

Submitted request contains GPS coordinates and a postal-code (geocoded from the coordinates).The proximate neighbors are resolved using this information by first retrieving the subset of users belonging to the same postal. Afterwards, Kd-Trees are constructed to perform a modified nearest neighbor search named ,*N Nearest Neighbors(NNNS)*search which discovers all neighboring entities within a specified radius from a target node[2].The Haversine Formula given below is used for distance calculations.

$$\text{haversin}\left(\frac{d}{R}\right) = \text{haversin}(\varphi_2 - \varphi_1) + \cos(\varphi_1)\cos(\varphi_2)\,\text{haversin}(\Delta\lambda).$$

The resulting entities are passed on to either the Semantic Similarity Module or the Semantic Opposites Module depending on the requested criterion.

F. *Natural Language Processing Core (NLP-Core)*

The NLP-Core provides the essential natural language processing features of the system. It uses components provided by the General Architecture for Text Engineering (GATE)including a tokenizer, a lemmatizer, a parts-of-speech tagger, a gazetteer and a sentence splitter[3].

In addition, it contains the Sententia Word Sense Disambiguator (SWSD) which is used to clarify the sense of a word in terms of a particular context within a sentence. It leverages the capabilities of the GATE Embedded API and the lexical database known as WordNet and uses an adapted version of the Lesk Algorithm introduced by Michael E. Lesk in 1986.

G. *Semantic Similarity Module (NLP-SS)*

This aims to couple one thought to another by calculating a semantic similarity quotient in order to serve collaboration requests marked with the similarity criterion.

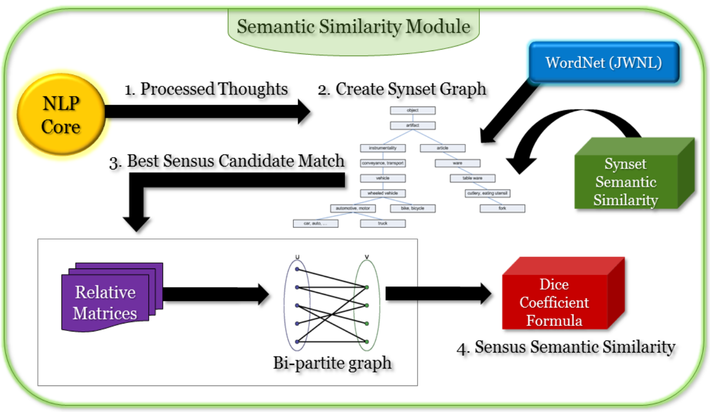

Fig.2. - Semantic Similarity Module Overview

The thoughts are passed through *Processing Resource Pipelines*inthe NLP-Core to create lexical graphs of *Synsets*. Edge costs between the synsets are measured and plugged into a relative matrix which is converted to a bi-partite graph.

The *Hungarian Method* is used to discover the best matching candidate among the synsets from each thought and the overall semantic similarity quotient is calculated using a dice coefficient formula[4]. If this exceeds a threshold, the two thoughts are deemed to be similar.

H. *Semantic Opposites Module (NLP-SO)*

Collaboration requests marked with the opposites criterion are processed via this module. It uses the NLP-Core and NLP-SSmodules during its procedure.

As a precursor to the opposites evaluation, the verbs associated with the service are separated from each thought and processed via the NLP-SS Module to compute a similarity measurement. An antonym evaluation will be performed if NLP-SS returns the verdict as “similar” and the final opposites coefficient determines whether a requirement was matched against a service.

I. *Multicasting Initiation*

The Multicasting Facet on the frontend allows the user to enter a thought and multicast it to all users within a specified or predefined distance.

Each individual is required to submit information which identifies a role played in society and his or her contribution to the said society. Multicasting performs a radius-restricted filtering involving the association of message content and an individual’s role information (via NLP) to resolve the most deserving receivers for the multicasted message.

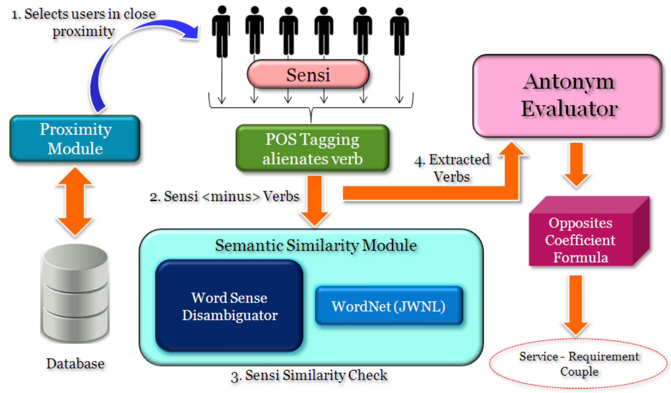

Fig. 3.- Semantic Opposites Module Overview

J. *Multicasting Module*

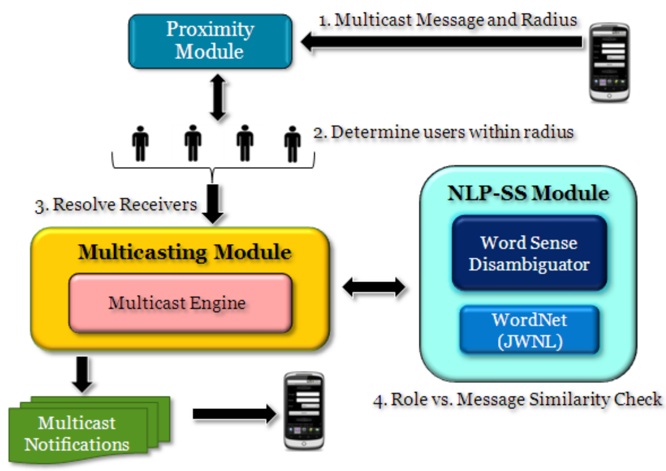

Fig.4. - Multicasting Module Overview

This is where the resolution of receivers for each multicasted message is performed.

The process uses a *Multicasting Engine* which communicates with the NLP-SS module to calculate similarity quotients between a multicasted message and all neighbors within the multicasted radius. Any resolved receivers are alerted via multicast notifications.

K. *Augmented Identification*

The use of Augmented Identification supplements the architectural models of section 2.1 by allowing one to visualize the digital identities of those in close proximity, superimposed with collaborative data, through the video feed of a mobile device[5].

The process is initiated on the frontend where the mobile camera feed is periodically sampled and the resulting images are transmitted to the backend *Image Processing Module*. It uses *Computer Vision* to detect faces and subsequently recognize them by cross-referencing the avatars in the database. The recognized avatars along with their thoughts and profile information are returned to the frontend where *Mobile Augmented Reality* is used to superimpose these data onto the live video feed.

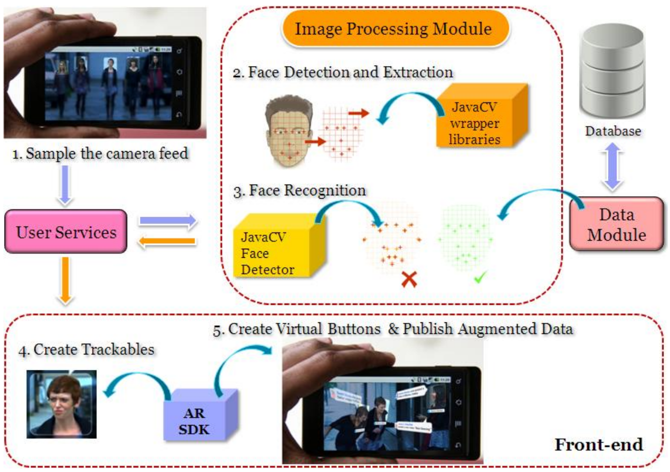

Fig.5. - Augmented Identification Module Overview

III. Results and Discussion

The accuracy of a thought matching procedure is dependent upon the user entering a thought in a textual format which can be processed via the NLP modules. Therefore, each thought is validated on the backend during collaboration initiation.

The similarity and opposite quotients were promisingly accurate; any impreciseness in existence was brought on by the limitations of the *Snowball Stemmer* component which was used as a lemmatizer.

Profiling information was gathered by exercising the system with thoughts of various types and magnitude. The revealed statistics were used in fine tuning the backend algorithms and optimizing them.

The proximity detection was a variable factor which proved to be dependent on GPS coverage and the availability of an A-GPS supported device which contributed to comfortable geolocation accuracies[6].

The richness of the service provided is proportional to the number of logged users in the immediate vicinity and a high user density will enrich the collaborative experience.

IV. Conclusion

The system architecture enables collaboration criteria to be coded and plugged into the system. This allows future expansion of the system by introduction of new conditions on which thoughts are coupled.

The current frontend implementation existent on Android could be ported to other platforms for broader availability. Certain core frontend components could be coded using the Android Native Development Kit (NDK) [7]and the common native code could be integrated on the other platforms with minimum alterations to provide a seamless user experience.

Currently, research in the field of Natural Language Processing [8]is in its infancy. This same goes for Augmented Reality (AR) and Human-Computer Interaction. With more research, the NLP components of Sententia can be adapted to handle various thought inputs with allowance for a wider range of human error. This permits the entry of free thoughts and eliminates the high probability of it being invalidated on the backend.

At a time when lightweight AR glasses become fashionable, the world you view would be populated with hundreds of virtual tags at a time, augmented IDs would pop-up from all around and service discovery notifications would marquee across the horizon. Sententia is but one step towards this future that we all envision.

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