Chapter 1

On the Notion of Collective Intelligence:
Opportunity or Challenge?

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ABSTRACT

In this article, the author explores the notion of Collective Intelligence (CI) as an emerging computing paradigm. The article is meant to provide a historical and contextual view of CI through the lenses of as many related disciplines as possible (biology, sociology, natural and environmental sciences, physics) in conjunction with the computer science point of view. During this explorative journey, the article also aims at pinpointing the current strengths and weaknesses of CI-related computational and system engineering design and implementation methodologies of CI-based systems. A non-exhaustive list of case studies set up the stage for CI applications as well as challenging research questions. These can be particularly directed towards the Social Web, as a very prominent example of synergistic interactions of a group of people with diverse cultural and professional backgrounds and its potential to become a platform for the emergence of truly CI-based systems.

INTRODUCTION

At the dawn of the 21st century, we are witnessing an ever increasing transition from personal computers to personalization of data, knowledge and contents in computing and computer science.

The emergence of the Social Web phenomenon as a realm of "linked people" and the vision of the Semantic Web as a realm of "linked data" already paved the way towards considerations of new forms of intelligence, which emerges from the "interaction of minds" paradigm. In this context, the role of humans as contributors to knowledge creation and collectively problem solving in a

networked society is being emphasized. The emphasis is also put on the role of computers as facilitators of learning and knowledge sharing in collaborative environments via multimedia enriched contents or games.

The transition, however, from personalized data, knowledge and contents towards collectively intelligent forms of synergies in an amalgamation of humans and machines, as a new paradigm of *Intelligence*, is at its infancy and raises many questions varying from the very notion of Collective Intelligence to the methodologies and principles for computations and engineering of CI-based systems.

In this article, an explorative journey through memories and approaches has been attempted in order to give some hints for finding some answers to the many questions ahead. In particular, an exploration of the definition of the term *Collective Intelligence* has been provided by first section. This section gives some overview of what is in the essence of this term to be coined as an umbrella of an intelligence paradigm through synergistic efforts.

Section 2 crosses the boundaries of computing and computer science and attempts to get to know the understanding and approaches of other disciplines such as biology, sociology, natural and environmental sciences, physics, towards the notion of collective systems and

(super-) organisms, in a hope that this interaction will shed more light into the dark side of the definition of Collective Intelligence.

Section 3, in turn, explores computational and mathematical underpinnings of Collective Intelligence in an attempt to highlight the impact and reflection of lessons learned from other disciplines with particular emphasis on natural, biological and sociological approaches to the CI-phenomenon. In addition, section 4 discusses and illustrates the lack of commonly agreed upon methodologies for the design and development of CI-based systems. Therefore, an attempt has been taken to set up a framework for the development of a CI

enabling methodology, which may depart from many conventional information systems design methodologies as known and practiced so far.

Section 5 embarks on the description of an indicative list of case studies and application areas with a twofold purpose: to highlight the many contributions CI-enabling systems may have in society and technology and to point at particular areas for investigation and validation of research questions in applied CI. Finally, section 6 summarizes in terms of interesting and open research questions.

1. ON THE DEFINITION OF COLLECTIVE INTELLIGENCE

According to a definition in Wikipedia "*Collective intelligence is a shared or group intelligence that emerges from the collaboration and competition of many individuals. Collective intelligence appears in a wide variety of forms of consensus decision making in bacteria, animals, humans, and computer networks - a field that studies collective behaviour from the level of quarks to the level of bacterial, plant, animal, and human societies.*"

Occasionally, the term Collective Intelligence appears to be a synonym of *Swarm Intelligence, Group IQ, Symbiotic Intelligence*. Our quest in Oxford English Dictionary, however, returns no entry for the term *Collective Intelligence*. Instead, terms like Central Intelligence Agency, Military Intelligence, Artificial Intelligence, SETI, Secret Intelligence Service, Nous and Intelligent Quotient are prompted as potential candidates of an answer to our quest.

However, if one attempts to reconstruct the meaning of Collective Intelligence from its compound terms *Collective* and *Intelligence* separately, then we would be tempted to adhere to "*understanding (from the Latin Intelligere) which belongs to or operated cooperatively by all members of a group as a whole or aggregate*". Further meanings adhered to the adjective *Collective* such as

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