The purpose of this paper is to provide the reader with an extensive technical analysis and review of the book, "Multi agent Systems: A Modern Approach to Distributed Artificial Intelligence" by Gerhard Weiss. Due to the complex nature of the topic of distributed artificial intelligence (DAT) and multi agent systems (MAS), this paper has been divided into two major segments: an overview of field and book analysis. The first section of the paper provides the reader with background information about the topic of DAT and MAS, which not only introduces the reader to the field but also assists the reader to comprehend the essential themes in such a complex field. On the other hand, the second portion of the paper provides the reader with a comprehensive review of the book from the viewpoint of a senior computer science student with an introductory knowledge of the field of artificial intelligence.

An Overview of the Field

Over the past two decades, the field of distributed artificial intelligence (DAT), an integral sub field of AI, has experienced exponential growth in the areas of research and development. DAT is primarily concerned with systems that consist of multiple independent entities that interact with each other in complex problem domains. The research area of DAT has been divided into two sub-disciplines: Distributed Problem Solving (DPS) and Multi agent Systems (MAS). The focus of DPS is on the information management aspects of systems where several agents are working together in a distributed manner towards solving a given problem and thus trying to achieve a common goal. On the other hand, MAS is related to DPS but is highly concentrated on the behaviour management aspect of groups of several independent entities or intelligent agents that are interacting with each other in a given problem domain.

Researchers in the area of MAS are primarily interested in studying the interactions of computational intelligent agents. These agents represent real world entities and have different preference composition. The key research goal in the area of MAS is to design distributed systems that lead to globally desirable outcomes for any problem domain. An interesting concept of MAS is that the participating intelligent agents can choose to consider their own good and thus may act insincerely. Furthermore, their interactions can be either cooperative or selfish, whereby each intelligent agent can either share a common goal or can practice its own interests. The successful implementation of MAS agents has been facilitated through researching essential components such as agent communications languages, interaction protocols and agent architectures. Due to the interdisciplinary nature of the field, researchers in the area of MAS explore on concepts and models from many disciplines outside of AT, including psychology, economics, philosophy, organization and management science. MAS technology is not merely a concept but rather it has several applications in the workforce and has been successfully implemented in areas such as networking, operating systems, marketing, finance, manufacturing, and logistics.
Book Analysis

The book, "Multi agent Systems: A Modern Approach to Distributed Artificial Intelligence" edited by Gerhard Weiss, focuses on many interesting issues and components that give rise to the emerging field of distributed artificial intelligence (DAT) by providing an extensive introduction to the concept of multi agent systems (MAS). The main purpose of the book is to provide researchers and practitioners with key sources of information on the technology of MAS, thus it is meant to be a textbook or even a self-study guide for the use in advanced undergraduate computer science courses. The book is a useful reference material not only for computer scientists and engineers, but also for social and management scientists as it makes references to theories and examples from various disciplines other than AI. It emphasizes aspects of both theory and application and provides many illustrations and examples in order to assist the reader in better understanding the proposed theories. Also included at the end of each chapter are thought provoking exercises of varying difficulty that further enhances the readers understanding of the reading material.

Unlike traditional textbooks, the book brings together the knowledge and expertise of many leading experts in the field thus guaranteeing a broad and diverse base of information. The textbook consists of 619 pages that have been compiled and encapsulated within 13 chapters. Each chapter in the textbook is written by a different author, who is a leading expert in that topic. Weiss has dedicated extensive attention in ensuring that all the chapters in the book flow in a logical manner so that the material in each chapter further develops on the concepts and material discussed in previous chapters. In my view, Weiss has been very successful in this attempt since, the overall flow of the chapters is very acceptable, even though at times the reader is able to notice certain inconsistencies in the notations used by different authors.

The book is divided into two parts. Part 1 contains the first nine chapters, each treating a core theme in the field of DAI and MAS. Chapter 1 concentrates on the "micro" or agent level systems, whereby these systems work independently to solve a given problem in any domain. Chapter 2 further expands this notion by focussing solely on systems of agents (i.e. "macro" or group level systems) and the computational infrastructure required for interaction among these agents. Chapters 3 to 6 address elementary activities of intelligent agents and how these activities have an impact on the successful implementation of MAS. Such activities include problem solving, planning, searching, decision making and learning. Chapter 7 focuses on how computational models can be used to encapsulate and illustrate the processes of organizing, as they occur among agents and humans. Chapter 8 describes formal methodologies for analysing and constructing various architecture components of agents (i.e., "micro" level) and multi agent (i.e., "macro" level) systems, while chapter 9 provides the reader with an overview of how MAS can be applied within the marketplace to further ensure its successful deployment. On the other hand, Part 2 contains chapters 10 to 13, which focus on closely related themes from the disciplines of computer science and software engineering. Furthermore, these chapters deal with groupware and computer supported cooperative work, distributed decision support systems, various issues of concurrent programming for DAI, and distributed control algorithms.

In my view, Weiss has very successfully selected these themes as they are highly relevant to the field of DAT and MAS, and this can be easily noticed. Since, coordination of activities is an essential component required by independent agents to effectively participate in a MAS, supports the need of
the theme for groupware and computer supported cooperative work as these technologies support the agents in acting rationally as a group and thus constitute an important application domain for MAS. Furthermore, intelligent agents have to collectively make decisions with other agents in order to produce successful and efficient MAS, which requires technologies that support the distributed decision-making process and thus solidifying distributed decision making as another obvious application domain for MAS. Evidently there is a critical need for powerful concurrent and parallel programming techniques that will assist in implementing MAS as distributed Systems. Furthermore, it can be noticed that the successful implementation of MAS technology is heavily dependent on the mechanisms and methods that enable agents to control their distributed computations, thus supporting the need of the theme distributed control algorithms. In my view, Weiss has very successfully selected these themes as they are highly relevant to the field of DAT and MAS, and this can be easily noticed. Since, coordination of activities is an essential component required by independent agents to effectively participate in a MAS, supports the need of the theme for groupware and computer supported cooperative work as these technologies support the agents in acting rationally as a group and thus constitute an important application domain for MAS. Furthermore, intelligent agents have to collectively make decisions with other agents in order to produce successful and efficient MAS, which requires technologies that support the distributed decision-making process and thus solidifying distributed decision making as another obvious application domain for MAS. Evidently there is a critical need for powerful concurrent and parallel programming techniques that will assist in implementing MAS as distributed Systems. Furthermore, it can be noticed that the successful implementation of MAS technology is heavily dependent on the mechanisms and methods that enable agents to control their distributed computations, thus supporting the need of the theme distributed control algorithms.

In the following sections, I will attempt to carefully analyse and examine the contents of chapters 1 to 8 in order to assess the relevance of the content to the theme of DAT and MAS. Furthermore, the evaluation will also heavily rely on how successful the author was in conveying his/her ideas to a particular target audience: undergraduate students in their senior year of university with knowledge of an introductory artificial intelligence course. Please note that only chapters T to 8 will be reviewed because these are the only chapters that deal with the essential technical concepts and components that are required to implement MAS, while the remaining chapters only provide information on the specific technologies that can be used to construct these components.

Chapter 1: "Intelligent Agents" by Michael Wooldridge

Chapter Summary:
The author aims to introduce the reader to the basic issues surrounding the design and implementation of intelligent agents or "micro" level agents. Furthermore, the behaviour and environment of the agent is also explored. The author points out to the reader the main differences between purely reactive agents, agents that separate perception and action, and agents with state. Furthermore, the reader is presented with some of the properties and importance of various intelligent agent architectures, such as logic based, reactive, belief-desire- intention, and layered architectures, which are used in the development of intelligent agents. The final portion of the chapter exposes the reader to agent-oriented programming and concurrent MetateM language.
Chapter Analysis:
In my view, the author was very effective in describing the core differences among various agent architectures through the detailed explanation of agents and their environment. The reader is exposed to various implementations and applications of agent architectures within the workforce, thus enlightening the reader to the fact that these concepts are not abstract in nature. Also, Wooldridge addresses the fundamental differences between agents and objects, which is a key question that has haunted many individuals who are new to the field of intelligent systems. The author is further able to successfully convey his ideas and the relevance of the content to the actual theme by the use of detailed and easily understood examples, which assists the reader in extensively understanding the material.

Chapter 2: "Multi agent Systems and Societies of Agents"
by Michael N. Huhns and Larry M. Stephens

Chapter Summary:
The notion of MAS is introduced within this chapter and thus the focus on individual agents is removed. The authors describe, analyse and propose a design of the environment in which agents can operate effectively and interact with each other productively. Furthermore, the study of agent communications and agent interaction protocols within the proposed environment are also discussed. Any sequence of communication that is carried out among intelligent agents for coordination purposes is termed by the authors as interaction protocols. Due to the nature of intelligent agents, which are participating in MAS, the coordination of these agents can either be selfish or cooperative (cooperation protocols), whereby each intelligent agent can either practice its own interests or share a common goal. The authors discuss the famous notion of divide and conquer, where complex problems are broken into similar sub-problems that are easier to solve. In the case of agents that coordinate for self-interest purposes, the chapter brings to the readers attention how individual agents can resolve their conflicting interests through the use of negotiation protocols such as multi agent belief maintenance and market mechanisms. In conclusion, the authors provide the reader with a brief discussion on the notion of societies of agents and its issues.

Chapter Analysis:
In my view, this chapter provides an excellent framework for the rest of the book. Most of the concepts and techniques that are introduced in this chapter are further expanded in later chapters. Since, the information presented by the authors is highly relevant to the field, I felt that the authors should have further elaborated on sections such as agent communication in order to provide the reader with enhanced understanding of the languages used for communication among agents. Furthermore, even though the purpose of the chapter was not to focus solely on agent communication languages, such as KQML, the chapter fails to provide detailed information to the reader that otherwise would allow the reader to fully understand KQML, for which reason I think the authors should have included supplementary material in the appendix on KQML as it is one of the most commonly used languages for agent communication. Overall, the categorization of the related materials further allows the reader to clearly understand the authors' analyses and design of the proposed environment.
Chapter 3: "Distributed Problem Solving and Planning" by Edmund H. Durfee

Chapter Summary:
Interaction protocols (chapter 2) allow MAS agents to communicate with each other in order to coordinate their actions for working together in achieving a common goal. Chapter 3 focuses on strategies for using protocols and reasoning capabilities to realize the benefits of cooperation. Distributed problem solving techniques focus on exploiting the distributed computational power of individual systems that are networked together in order to solve problems in a complex problem domain. The chapter describes the task sharing process within heterogeneous systems, distributed sensor networks, and the task sharing of interdependent tasks. The author then brings to the reader's attention the concept of result sharing, which involves deciding how agents that might be working on pieces of larger task can discover the relationship among their activities and coordinate them. The chapter provides the reader with a detailed overview on how result sharing is performed in areas such as functionally accurate cooperation, negotiated search, distributed constrained heuristic search, organizational structuring, communication strategies and task structures. The final sections of the chapter concentrate on distributed planning and execution. The author provides a clear distinction between the planning process and execution of plans, whereby either, or both, could be distributed. Techniques dealing with each one of these are presented within the chapter. The chapter concludes by considering how execution when mixed with planning and coordination can complicate matters, and for which reason the author presents the reader with algorithms that ensure interleaving of planning, coordination and execution for dynamic applications.

Chapter Analysis:
The author presents the reader with various examples and applications of distributed problem solving, which assists the reader to comprehend the importance of these concepts to the successful implementation of MAS. In my view, the material covered in this chapter is highly representative of the critical development and research performed in the area of distributed problem solving, thus providing the reader with up-to-date information on the field. The chapter provides an in-depth and concise focus on DAI planning. This requires the reader to have a firm understanding of traditional AT planning techniques, which most undergraduate computer science students tend to lack as AT planning is not covered within the introductory AI classes. In my view, the chapter would be more effective if it could provide the reader with a brief review of AI planning techniques, through the use of examples, as this would help the reader in better understanding the material covered in the later parts of this chapter.

Chapter 4: "Search Algorithms for Agents" by Makoto Yokoo and Toru Ishida

Chapter Summary:
The notion of searching is a universal problem solving approach in the field of AT, where the sequence of actions required for solving a problem cannot be known in advance but must be determined by searching through and exploring alternatives within the problem space. The chapter begins by introducing the reader to one of the most common types of problems that are faced by intelligent agents, i.e. the constraint satisfaction problem. The objective of search algorithms within a constraint satisfaction problem is to find a combination of variable values that satisfies the given constraints, as demonstrated by the N-queens problem. The authors provide details of some searching
algorithms and how MAS can discover optimal solutions for constraint satisfaction problems through the use of these algorithms. Also provided are pseudo-codes for some of these search algorithms such as are filtering algorithm, the hyper-resolution-based consistency algorithm, asynchronous backtracking, and asynchronous weak-commitment search. Additionally, the chapter presents the path-finding problem, where the goal is to find a path from a given initial state to the desired (i.e. goal state). Some of the searching algorithms that provide solutions to path-finding problems are asynchronous dynamic programming, learning real-time A*, real-time A*, moving target search, and real-time bidirectional search. The last section of the chapter exposes the reader to two- player games and minimax with alpha-beta pruning. These two-player games deal with situations in which two competing agents exist, most traditional algorithms were originally developed for single- agent problem solving.

Chapter Analysis:
One of the main strengths of the chapter was in its ability to provide the reader with actual algorithms and applying them on simple problems that can be easily understood and implemented, thus making the chapter very interesting to read and comprehend. Another strength of the chapter was to present the reader with pseudo-code that can effortlessly be converted into working code by a reader with minimal programming background. This not only allows the reader to test the properties and strengths of the algorithm but also assists the reader in enhancing his/her understanding of the importance of the algorithm in the successful implementation of MAS technology. The authors do a very good job in providing the breadth and appropriate depth for searching components in MAS. The material is presented in such a form that makes it easy to understand for a reader with introductory Al knowledge. However, I felt that the authors should have explained to the reader how traditional searching algorithms (such as depth-first search, breadth-first search, hill-climbing, genetic algorithms and A* search), which are used by individual agents for problem solving, could be modified such that they can be used in MAS. In my view, this distinction would enhance the readers understanding of the main properties that are essential and thus required to build searching algorithms for MAS as apposed to individual agents. Furthermore, the authors failed to mention how the notions of problem reduction and search space play an integral role in problem solving using searching algorithms. In my opinion, these notions are important not only because they affect the choice of searching algorithms that should be used for the implementation of MAS, but also because they affect the time and space complexity required for the multi agents to solve problems in very complex problem domains. The authors do not provide a strong argument as to why two player games are relevant to MAS, thus making this section feel out of place. Overall, the content covered in this chapter conforms to the modern developments in this field, thus allowing the reader to read about technology that is commonly used for the implementation of MAS.

Chapter 5: "Distributed Rational Decision Making" by Tuomas W. Sandholm

Chapter Summary:
Multi agent systems consisting of self-interested agents are gaining increasing popularity due to the growing communication infrastructure over which separately designed agents belonging to different organizations can interact in an open environment in real-time basis. Furthermore, the increase in demand for self-interested agents is also due to the fact that there exists a strong application pull for computer support for negotiation at the strategic and operative decision making level. The chapter
focuses on methods for making socially desirable decisions and negotiations among rational agents that only care of their own good, and may act insincerely to promote it. The reader is introduced to some of the evaluation criteria that could be used for rational decision making. These include social welfare, individual rationality, computational efficiency, and communication efficiency. The author then brings to the readers attention some of the methods, such as voting, bargaining, market mechanisms and coalition formation, that could be used by entities (such as humans or intelligent agents) for carrying out negotiations. The chapter thoroughly discusses each negotiation method by providing details on the advantages, issues and sample protocols for the methods. The chapter also heavily focuses on the topic of game theory, which is a resultant of microeconomics. In game theory, special emphasis is placed on the implications of limited computation on the classic results as it is highly correlated to the design and performance of computational MAS.

Chapter Analysis:
Due to the nature of the topic, the chapter exposes the reader to several concepts in the field of economics, utility theory, and game theory. The relevance of the material is obvious, but in my opinion the depth of these concepts requires the reader to attain background information in economics and utility theory. In my view, the reader could more effectively comprehend these concepts if the chapter had provided the reader with a brief introduction to these concepts before exploring them in great depth. As mentioned in previous chapters, the chapter should illustrate to the reader the importance of each mentioned algorithm by applying it to simple examples in order to enhance the readers understanding regarding the importance of the algorithms in the implementation of MAS. Overall, the chapter covers an extensive amount of research that has been conducted in the field of distributed rational decision making, however, the chapter fails to provide an introductory level explanation thus forcing the reader to resort to additional sources of information in order to get a clear understanding of the material.

Chapter 6: "Learning in Multi agent Systems" by Sandip Sen and Gerhard Weiss

Chapter Summary:
The chapter starts with a more general characterization of learning in multi agent systems. This includes the identification of principle categories of learning, an overview of the different features that help to structure the broad variety of forms of learning that may occur in MAS, a description of the basic learning problem known as the credit-assignment problem. The chapter introduces the reader to the theory of reinforcement learning in the viewpoint of individual agents and societies of agents. The authors move from this type of learning and focus on learning techniques that can be used by intelligent agents to learn from and about other intelligent agents. This section of the chapter presents various types of methodologies that can be used by intelligent agents to construct models about other agents. Furthermore, the section also discusses the utility of this approach for achieving coordination among agents. The next section of the chapter illustrates to the reader that there exists a positive correlation between learning and communication, i.e. agents can improve the quality of their communication as the level of learning that they have acquired has increased. The chapter concludes by offering a brief to relevant related work from machine learning, psychology and economics, and shows potential directions of future research.
Chapter Analysis:
The chapter is very successful in effectively introducing the reader to the topic of learning. One of the major strengths of the chapter was in its ability to provide the reader with a basic description of reinforcement learning within individual agents before expanding the concept to agents participating in MAS, as I had advised for searching algorithms. This helps the reader to understand the core differences in how individual agents as opposed to MAS learn about their environment. However, I felt that some of the complex concepts and algorithms that were presented within the chapter lacked detail, thus making it difficult for the reader to fully understand how these techniques could be used to not only implement MAS but also to solve simple problems. If the reader is able to comprehend these learning algorithms then he/she is able to make the decision regarding which learning algorithm should be used for what type of agent under a given problem domain. In my view, this chapter required the reader to attain background information on machine learning since the authors made extensive references to machine learning when explaining its relationship to MAS.

Chapter 7: "Computational Organization Theory" by Kathleen M. Carley and Les Gasser

Chapter Summary:
The chapter provides an overview of the emergent field of computational organization theory (COT). Researchers in COT use mathematical and computational models to analyse organizations and the process of organizing. Research in this area blends some of the traditional concerns of AI and distributed computing with work by organizational and social theorists, to develop a more comprehensive understanding. In most of this work, organizations are characterized as MAS in which agents are embedded in particular social roles, have particular cognitive capabilities, and are engaged in specific organizationally-relevant tasks. This chapter provides some common approaches and models that are used in this area, along with potential toolkits, new findings, directions and trends. The authors discuss how COT can be used with mathematical and computational methods to analyse humans and automated organizations in the light of computational entities. Also, illustrated are some of the advantages and disadvantages of using certain modelling approaches over others. The chapter brings to the readers' attention how certain concepts such as agents, organizational design, and technology, can be used for modelling organizations. The chapter concludes by presenting a thorough discussion on the methodological issues that arise in COT, which include the use of virtual experiments, the problem of validation and verification, and the use of computational frameworks.

Chapter Analysis:
In my opinion, the chapter presumes too much familiarity with COT literature, which is not introduced to readers in introductory AI courses. The main failure of the chapter also lied on the fact that the authors discussed the advantages and disadvantages of several COT models without providing any detailed explanation of the models. Furthermore, the chapter lacked examples and applications that otherwise could have been used by the reader to acknowledge the concepts presented in the chapter. Also, the lack of examples and concrete applications of COT forces the reader to visualize the material as being abstract in nature as he/she is unable to relate it to real world implementations of COT. The authors did not provide any computational aspects of COT such as equations or algorithms. Such shortcoming does not allow the reader to test the concepts and therefore, the reader is unable to acquire an appreciation of COT.
Chapter 8: "Formal Methods in DAI: Logic-Based Representation and Reasoning"
by Munindar P. Singh, Anand S. Rao, and Michael P. Georgeff

Chapter Summary:
The chapter begins with background information on some logics that are commonly used in traditional computer science programming applications. It presents DAI-specific enhancements to these logics, covering the concepts of knowledge, beliefs, desires, goals, and intentions. In order to give a flavour of how the formal techniques might be applied, this chapter also describes how the above concepts might be realized in a particular interpreter. Furthermore, this section of the chapter uses a logical framework to give a detailed introduction to BDI architectures. It also discusses a range of additional phenomena, such as coordination, teamwork, interagent communications, and social primitives, all using the same logic framework. In conjunction with concepts such as joint and group intentions, which lift single-agent primitives to MAS, these topics provide the essential conceptual basis for MAS. This chapter concludes with a discussion of tools and systems that either directly implement the associated DAI-specific formal theories, are inspired by those theories, or bring in traditional formal approaches. Furthermore, overviews are provided of some of the commonly used agent architectures and tools, such as PRS, dMARS, COSY, AGENT0, and ARTIMIS, which are based on principles of logic.

Chapter Analysis:
Similar to some of the previous chapters, this chapter also requires the reader to attain background knowledge on logic representation and reasoning. In this case, the main areas of logic that the reader would require background information on are predicate, modal, and temporal logics. The chapter attempts to provide the reader with a brief overview of the different types of logics but I found the overview to be insufficient based on the demand that the chapter puts on the reader. However, readers with basic knowledge of logic representation, acquired during introductory AI courses, should be able to understand some but not all of the logic-based architectures that are presented in this chapter. Thus, the main challenge that lies for the reader is to fully comprehend the logic theorems that are quickly presented in the introductory section of the chapter in order to understand the later parts of the chapter. Overall, the content covered in this chapter conforms to the modern developments in this field, thus allowing the reader to read about concepts that is commonly used for the implementation of MAS.

In summary, I felt that this book provided its target audience with an excellent source of information on the technology of MAS and DAI. Due to the complex nature of the field, the reader would require some background information on various disciplines such as AI, Economics, game theory, computational organizational theory, machine learning, and logic. Additionally, the book demands the reader to acquire knowledge of specific literature, algorithms, and theorems that are covered in each of these disciplines. The content presented in the book is very thorough and up-to-date with the latest research and developments in the field of DAI and MAS. Overall, I found the book to be very successful in attempting to cover the relative breadth and depth of all the areas of MAS and DAI, especially given the fact that the research in the field is very broad and not fully formed.