Project Summary

In the last 30 years, logic programming (LP) has emerged as a powerful paradigm for intelligent reasoning and deductive problem solving. In recent years, several powerful and highly successful extensions of logic programming have been proposed. These include constraint logic programming (CLP), tabled logic programming, inductive logic programming (ILP), concurrent/parallel logic programming, Andorra Prolog, and extensions for non-monotonic reasoning—e.g., answer set programming (ASP). These extensions have led to powerful applications, such as in planning (ASP), model checking (tabling, CLP), semantic web (tabling, ASP), machine learning (ILP), intelligent scheduling (CLP, Andorra).

Unfortunately, all the powerful extensions of LP have been developed by extending standard LP (Prolog) systems, and each one has been developed in isolation from others. While each extension has resulted in very powerful applications, considerably more powerful applications would become possible if all these extensions were combined into a single system. This power will come about due to the interplay between the features offered by the different extensions, leading to enhanced declarativeness (programmers are relieved from the burden of low-level control issues) and considerable improvement in performance (achieved through dramatic reduction in search space and parallelism). Researchers are indeed feeling the need for advanced LP systems that combine the various advanced features, while developing applications in important areas such as the semantic web, knowledge discovery, and software modeling and verification.

**Our Insight:** Realizing multiple or all extensions in a single framework has been rendered difficult due to the considerable complexity of implementing logic programming systems. Extending a standard logic programming system to incorporate each extension, e.g., constraints, tabling, or parallelism, is a complex and challenging task; therefore, implementing all the different extensions all together in a single system has been traditionally viewed as a formidable task, that will require years of development time. As a result, despite the obvious advantages of incorporating all extensions in the same system, researchers have not ventured further. Our main insight, on which the proposed research effort will be based, is to design extremely simple yet efficient implementation techniques for incorporating each of the extensions in a Prolog system. These techniques build on the understanding of the underlying execution issues of the different extensions acquired through years of research and on novel designs that exploit reusability of implementation techniques across different extensions as well as orthogonality of execution mechanisms. The proposed techniques can be incorporated in any existing Prolog system in 2 to 3 man months of work. Thus, any existing Prolog system can be extended with all the advanced features in a short time, permitting extremely powerful applications to be developed elegantly. We have already have had some success in designing such implementation techniques in the past; some of these techniques have already been adopted by others due to their simplicity.

**Research Contributions:** In this project we will develop the “next generation” logic programming system that incorporates these simple-to-implement techniques for the various extensions. This next generation system will be obtained by extending YAP Prolog with these techniques. We will also develop a number of advanced applications in diverse areas to highlight the power of our next generation LP system. The resulting system will be made publicly available. Our claims to innovation are as follows: (i) The simple, novel and efficient implementation techniques we will develop will allow various extensions of LP mentioned above (Constraints, Tabling, Andorra, Parallelism, ASP, ILP) to be easily amalgamated into a single system, allowing very powerful deductive procedures to be efficiently programmed. The criteria of simplicity will be that each of the method can be incorporated in an existing Prolog system with just a few man-months of effort; (ii) The resulting next generation logic programming system that amalgamates the various extensions mentioned above will allow highly complex, practical problems, to be programmed in an efficient manner. The criteria of success of our system will be to solve large, highly complex, practical problems in considerably shorter time (both in programmer’s time as well as CPU time) than they can be currently solved.

**The Research Team:** The research team will consist of three U.S. PIs: Dr. Gupta (UTDallas), Dr. Pontelli (NMSU), and Dr. Guo (U. Nebraska). They will be joined by Dr. Santos Costa (Federal Univ. Rio de Janeiro), their long time collaborator, who will spend 3 years as a post-doc researcher at UTDallas. All the researchers have spent their careers researching and building advanced LP systems and their applications. They have designed implementation techniques that have been adopted by others, as well built a number of LP systems that are publicly available. The researchers will be assisted by half a dozen Ph.D. students and an equal number of M.S. students at the 3 institutions involved.

**Broader Impact:** Our research will advance the state-of-the-art in logic programming research and implementation. It will also have an impact in a number of allied areas, such as the semantic web, in which logic and logic programming based techniques form the basis of various applications. Areas such as program verification, AI, planning, and machine learning will also be impacted. LP is a recognized high-impact research area, and the proposed effort will enhance U.S. competitiveness in this field. Our research will involve a diverse student population—New Mexico State University is a designated Minority Institution, while UTD has 21% minority student population. The research will also involve undergraduate students. Additionally, NMSU and UNO are universities located in NSF EPSCOR states, and thus cooperation between the 3 universities involved will be beneficial in developing research competitiveness.