

# **SOME SYSTEM - THEORETIC INVESTIGATIONS FOR THE ANALYSIS OF COMPLEX SYSTEMS**

By  
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## CERTIFICATE

It is certified that the thesis entitled "SOME SYSTEM THEORETIC INVESTIGATIONS FOR THE ANALYSIS OF COMPLEX SYSTEMS" being submitted by Mr. LM Chelapa for the award of the degree of DOCTOR OF PHILOSOPHY is a record of student's own work carried out by him under my academic supervision and guidance.

To the best of my knowledge, the contents of this thesis have not been submitted anywhere else for the award of any other degree.

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DEDICATED

to all those parents who love  
their children

AND

to all those teachers who care  
for their students

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Right from the word "GO" it had been a long and interesting journey with plenty of 'downs' and 'ups'. Prof. PS Satsangi skillfully applied breaks when things were going down the hill at full speed and added a double engine when things went panting uphill, but on the plains he just gave a pat on the back and said 'Boy! You are doing fine. Keep it up'. No wonder he is a gem.

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## ABSTRACT

The proposed study is an attempt to apply relevant concepts, tools, and methodologies of system engineering for the analysis of widely disparate complex systems. The research investigations have been divided into three parts, viz., transportation systems, education systems, and music systems. All these systems can be classified as semi-abstract systems. However, in this study, transportation systems have been analyzed more at the physical system theoretic level following Satsangi's approach [Satsangi PS 1969] rather than at the abstract level. Education and music systems have been dealt with more or less at the semi-abstract level such that the qualitative aspects have been brought into sharper focus compared to the study of transportation systems.

The organization of the research presentation in this thesis is structured as follows. The thesis begins with an

introductory chapter describing briefly the general systems theories where systems have been classified into physical, semi-abstract and abstract systems. Having discussed general systems theories it goes on to enumerate the present research trends in rural & urban transportation systems, qualitative and quantitative aspects of education systems and select music systems.

Chapter 2 deals with the methodologies employed in this thesis, viz, Prim's algorithm, gravity model, taxonomies of educational objectives, interpretive structural modeling, content analysis, fuzzy set\_theoretic methodologies in decision making, fuzzy measure of difficulty, fuzzy algorithms and knowledge based computer systems (KBCS).

Chapter 3, as the first chapter of Part-I of the thesis, presents "quick-response" land-use transport planning models for Indian cities. These models recognize that urban transport is a function of the size of the urban settlements, form of the cities, structure and socioeconomic base. Based on the generic forms, Indian cities have been classified into circular, semicircular and linear cities. Now taking the structure into account by way of single central business district (CBD) or a combination of CBD and district business centers (DBC's), gravity models have been developed for Indian cities of the above forms. These models have been simulated for different population ranges whereby future estimates of the major corridor trip

volumes and lengths in the context of the transport requirements for the various metropolitan cities of India in 2001 A.D. have been made. These estimated results tally fairly well with the observations based on sample measurements.

The next chapter, namely chapter 4, deals with the socioeconomic aspects of rural road transport network planning. A detailed description of the transport priority Index (TPI) model has been presented. This TPI model is used to compute the transport priority indices for the villages in a district. The model is calibrated such that a village with a higher TPI has a higher priority to obtain road connection. Various subsystems such as the demographic subsystem and the agricultural subsystem provide the inputs to the calculation of TPI. Based on the TPI model an interactive package has been developed using Turbo PASCAL on an IBM compatible PC-AT. This package uses Prim's algorithm, which uses the distance between the villages as the weights on each link, in order to obtain an optimal rural road network plan.

Chapter 5, i.e., the first chapter of Part-II, concerns itself with the structural aspects of the Indian technical education system. An interpretive structural model [Warfield JN 1974b] of the objectives of the technical education system based on the new educational policy of the Government of India has been formulated. On the basis of an examination of the present structure

with particular reference to its lack of coordinating mechanism between the financial control and the academic control, a different structure, keeping in view the new education policy of the Government of India, has been proposed. This should ensure building in an adequate coordination mechanism which would achieve a higher quality output in a cost-efficient manner. Technical universities have been recommended as the bodies which can take up the desired role of envisaged responsibility.

Chapter 6 discusses the qualitative aspects of the technical education system. For this purpose, the technical education system has been divided into two conceptual subsystems, viz., the learning subsystem and the physical subsystem. The learning subsystem concerns itself with the activities of learning whereas the physical subsystem is concerned with the physical attributes of the technical education system which are supportive in nature for the learning process to take place. In order to qualitatively evaluate these systems, quality indices have been developed. Those indices concerning the learning subsystem have been named as the quality factors and those concerning the physical subsystem have been termed as quality indicators. Taxonomies of educational objectives both in the psychomotor and cognitive domains have been employed to derive the eight quality factors. The other set of eight quality indicators have been derived by observing the day-to-day functioning of the technical education system. A content analysis of the

library holdings has been performed in order to obtain an evaluation regarding the emphasis that is being laid on the quality factors by the library holdings, viz., text books, journals etc. The evaluation of the technical education system w.r.t quality factors has been performed both at the micro and macro levels. Towards the micro-level investigations, an electrical engineering undergraduate curriculum has been evaluated and these results have been compared with the evaluation at the level of courses. At the macro-level of the spectrum, the evaluation of the Indian technical education system w.r.t quality factors has been undertaken. Next, a particular educational institution has been evaluated w.r.t both the quality factors and the quality indicators. All these evaluations have been carried out using the fuzzy set-theoretic approaches.

In the last chapter of this part, i.e., chapter 7, a Degree of Difficulty (DoD) for fuzzy systems has been proposed following Kulkarni's definition of DoD [Kulkarni VB, et.al. 1985]. This is then used to estimate the DoD of the Indian technical education system.

Part-III, which consists of only one chapter, viz., chapter 8, presents the application of fuzzy algorithms and Knowledge based computer systems (KBCS) to the generation of musical patterns. Having discussed the Hindustani (Indian) musical terminology, the concept of a raga (melody) and the steps

involved ('aalap', 'jod', 'jhala', etc.) in the rendering of Hindustani classical music have been enumerated. It has been shown that the generation of the 'swara-vistaar' patterns is a fuzzy phenomenon. A KBCS has been developed to generate 'swara-vistaar' patterns for a select raga.

Chapter 9, the last chapter of the thesis, presents the conclusions and discusses the scope for further research.

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