OPTIMIZATION DEVELOPMENT OF EXTREME RISKS IN CRITICAL INFRASTRUCTURE CONSTRUCTION PROJECTS

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ABSTRACT
Construction equipment plays vital role for development of Infrastructure. Construction equipment's operational cost contributes 36 percent of the total project cost. Hence effective equipment management plays important role in infrastructure project management resulting into the substantial cost saving. Critical infrastructures like our power generation facilities and water supply form highly interconnected networks that are mutually dependent and any failure can cascade through the network, resulting in devastating impact on health, safety and the economy. These catastrophic events/disruptions can be triggered by environmental accidents, geological/weather phenomena, disease pandemics, etc. The disruptions can be caused/exacerbated by their being unexpected, but they may actually be expected if relevant data have been accounted for. To help account for and thereby anticipate such disruptions, one way is to identify potential unforeseen interdependencies among infrastructure components that can lead to extreme disruptions upon some failure in the network. This paper shows how a simulation model for cascading failures and a risk analysis/optimization approach can be applied to search for unforeseen interdependencies and failure points that give rise to the highest risk in a network. Critical path method is applied for the time and activities scheduling along with construction equipment allocation for both the project. During study float availability is identified as main influencing factor and the same is analyzed to optimize the construction equipment in infrastructure project.

Key Words: Construction, Equipment, infrastructure, Project, Management, Float, Optimization.

1. INTRODUCTION

Critical infrastructure refers to the assets, systems and networks comprising identifiable industries, institutions and distribution capabilities that provide a reliable flow of goods and services essential to the functioning of the economy, the government at various levels, and society as a whole[1]. Examples of critical infrastructure include facilities for energy/power generation, water supply, telecommunications, transportation, banking/financial services, security and health services, etc.[2]. They are highly interconnected and mutually dependent in complex ways, and the sudden unavailability of any of them or part thereof may cause loss of life, severe impact on health, safety or the economy[3,4,5]. The 9/11 terrorist attacks, the Indian Ocean tsunami of December 2004, the Hurricane Katrina devastation of the US Gulf Coast in 2005, the 2008 Global Financial Crisis, the 2011 Tohoku earthquake/tsunami and the severe flooding in Thailand late 2011 can be considered examples of such major disruptions/disasters. Effective project management is the most important factor to accomplish infrastructure development target set by Government of India. Construction equipment plays vital role in infrastructure construction. In this research paper we have considered two infrastructure (highway development) projects. Project details are as follows:

A. Four laning of NH-4A (NH-748) between Km.118/000 to 125/000 including construction of high level four lane new khandepar bridge at Km.118/800 in the state of goa.

B.Construction of Canacona National Highway Bypass from km. 68/00 (chainage 00/00) to km. 85/740 (chainage 7/740) on NH-17 (New NH-66) on P.m section in the state of Goa.

We have applied Primavera 6.0 R8.4 for complete project planning of both the project. Critical path method applied for calculating the time span of the project. Activity with free float identified to carry out analysis reducing the substantial cost towards construction equipment operation for both the projects.

2.LITREATURE REVIEW

We have reviewed various research paper and books buy various authors on highway project management using critical path method. Major finding are as follows:

CPM Analysis of Rolai-Rinjlai Road Construction: Research paper work is based on empirical data of a part of the Rolai-Rinjlai road construction project, in which raw material is available at different quarries providing different options to the contractor. Considering the project as a network, author used CPM technique in an attempt to obtain the critical path of the network and suggested the best approach for acquiring material and construction of road under the stated constraints. Author used crashing to further reduce the project completion time. CPM assumes that each activity has available - all the resources needed to perform the activity in the normal way (or on a crashed basis). In this study, a small amount of overlapping i.e. simultaneously laying the same layer at different spots has provided the slack/float needed to compensate for the “unexpected” delays that inevitably seem to slip into a schedule. Schedule proposed by us provides much shorter completion time as compared to the actual time taken by the project and paves the way for use of CPM scheduling for road construction projects to be a lucrative and viable option.

Critical Path Method: The Project Management Body of Knowledge (PMBOK), an internationally recognized collection of processes and knowledge areas accepted as best practice for the project management profession, defines the critical path as “the sequence of scheduled activities that determines the duration of the project.” It is the longest sequence of tasks in a project plan that must be completed on time in order for the project to meet its deadline. If there is a delay in any task on the critical path, then your whole project will be delayed. Although many projects have only one critical path, some projects may have multiple critical paths.

3.OPTIMIZATION AND ANALYSIS OF INFRASTRUCTURE NETWORK DISRUPTIONS

The network model of critical infrastructures comprises the infrastructure assets/components (nodes) and the links representing their interdependencies, as illustrated in Figure 1(a) (for only three infrastructure sectors). The study of the critical infrastructure vulnerabilities is based on a risk analysis framework, where risk can be defined as risk = f (probability, impact), i.e. as a function of the probability of a failure/hazard/threat resulting in an adverse event and the severity/impact of that event[10,9,8,7].

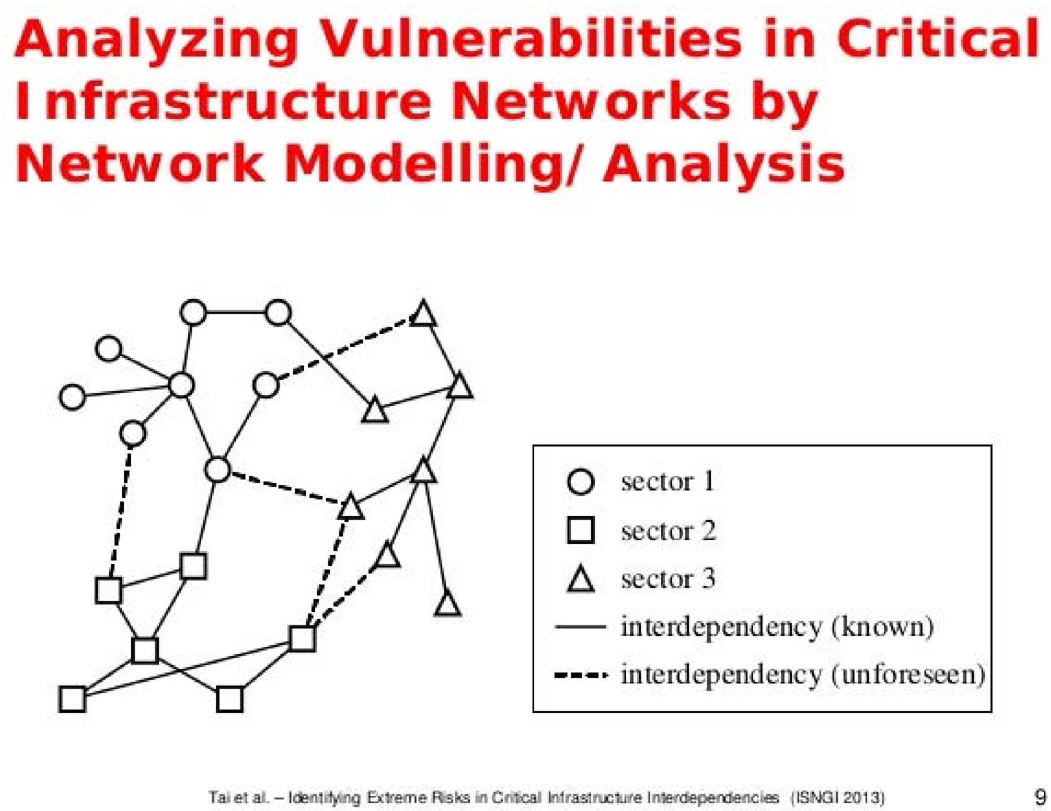

Figure 1. (a) Critical infrastructure network model

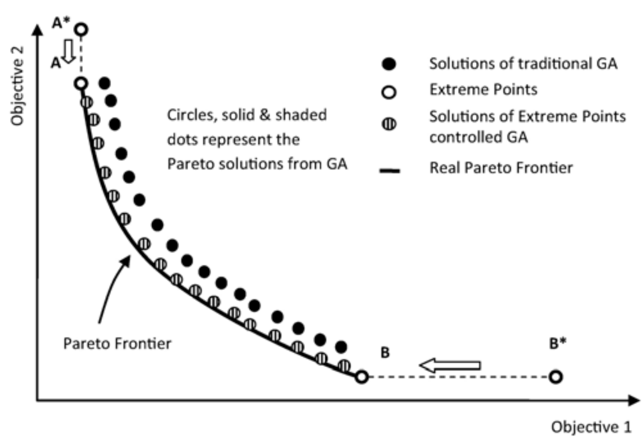

Figure 1. (b) Pareto optimal solutions of the network solutions of extreme

In the context of our problem, impact refers to the magnitude of the disruption in the network computed according to various metrics used in network theory such as, e.g. the giant component size[12,13]. Probability refers to the probability of the failures propagating/leading to the disruption. The optimization problem is therefore a problem of searching for networks and failures that maximize the two objectives of probability and disruption, with the decision variables being the unforeseen (variable) interdependencies and failure points within the network. With two objectives, an evolutionary algorithm is used to iterate a population of solutions (i.e. a set of networks with corresponding failures) converging towards Pareto-optimality. In this way, optimization has been used to synthesize networks with the highest risk, while those with the extreme disruption impact can be considered the Black Swan events, as summarized in Figure 1(b).

4.RESULTS FROM EXPERIMENTAL CASE STUDY

The proposed methodology was applied to an experimental case study with a network comprising 43 nodes with two variable (unforeseen) interdependencies added to the fixed (known) interdependencies. The results show that unforeseen interdependencies can indeed exacerbate the disruption consequences/impact, where impact is quantified by the giant component size (the smaller the size, the greater the impact). The plot in Figure 2(a) shows the optimal solution points obtained, with a line drawn through the Pareto-optimal solutions to represent the Pareto-front. The point at the lower extreme left is the Pareto-optimal solution with the greatest disruption (giant component size of 0.1), hence it can be interpreted as a Black Swan event, and it represents the scenario where failure occurs at node 30 and where there are two unforeseen interdependencies as shown by the thick black lines added to the network in Figure 2(b).

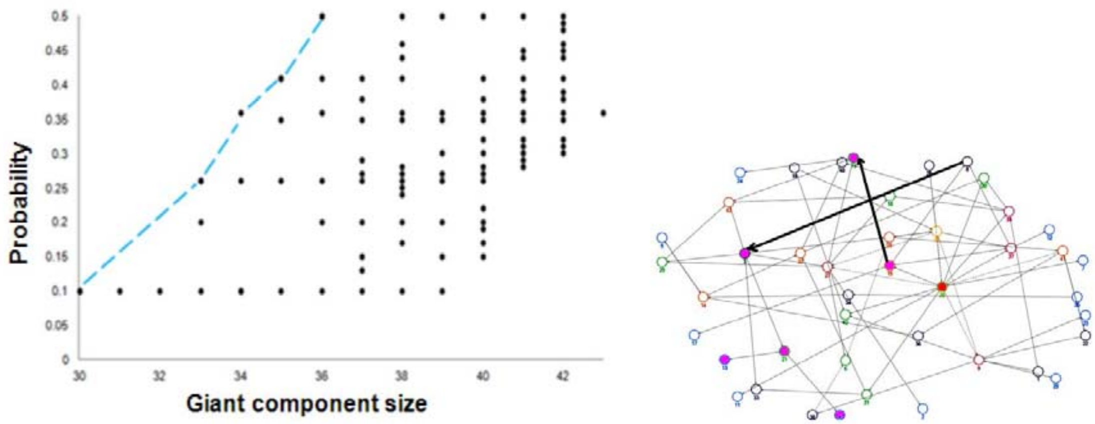

Figure 2. (a) Pareto-front of the multiobjective optimization of probability and disruption impact (giant component size) (b) Network with two unforeseen interdependencies added.

5.CONCLUSION

Construction equipment are the primary requirement of all infrastructure project. Effective management of construction equipment ensured timely delivery of infrastructure project within the contractual cost. In this research paper we have carried out the potential of construction equipment sharing model between two highway and bridge project in Goa. We have used critical path method. Primavera 6.0 R8.4 applied for schedule preparation. Activity with free float considered for sharing of construction equipment. Free float utilization will be resulting in substantial cost saving for the project. Considering both the project weightage of construction equipment is 37% of the total cost. Cost towards major plant installation and operation turns around 25% of the total project cost. By assuming that a significant part of the network interdependencies is in fact unknown (unforeseen), the proposed approach applies optimization to search for unknown interdependencies and failure points that will cause extreme events, thus leading analysts on a focused exploration of 'what-if' scenarios of high disruptive impact. In addition, it provides policymakers with a way to analyse the 'trade-off' between the high-probability/low-impact and the low-probability/high-impact events.

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