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# IMPROVING MOVING BLOCK RAILWAY SYSTEM USING FUZZY MULTI-AGENT SPECIFICATION LANGUAGE

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Abstract. *Railway interlocking system is a distributed, safety, monetary and environmentally critical system and its failure may cause the loss of human life, severe injuries, loss of money and environmental damages. The complexity of this system requires formal modeling and step by step refinement for its construction and development. The formal specification-based languages, such as* ***VDM****,* ***Z****-notation and* ***RAISE****, have been used for its modeling using crisp (two-valued logic) theory. However, due to the continuous and inexact features, like speed, weight and moving block (breaking distance including length of a train), fuzzy distributed multi-agent approaches are required to capture the inexactness and uncertainty present in the existing system. In order to get a fuzzy distributed multi-agent environment, we have extended the Object-**Z** towards the fuzzy multi-agent specification language (**FMASL**) using an integration of fuzzy logic, multi-agent systems (**MAS**) and Object-**Z** to be applied for the railway interlocking system. Initially, our extended approach is applied for the specification of railway crossing, a critical component of interlocking system. We have supposed that a train is an autonomous intelligent agent and has fuzzy sub-agents: a moving block and a crossing intelligent agents.*
**Keywords:** Formal specification, Object-**Z**, Fuzzy logic, Multi-agent systems, Moving block interlocking system

## 1. Introduction.

Railway interlocking is a safety, monetary and environmentally critical system. Its malfunction can cause very serious consequences such as loss of human life, severe injuries, large scale of environmental damages and considerable economical penalties. The use of computers in such systems has increased the concern for the safety of these systems. Much of this concern has been focused on the software component of the computer based complex systems. Primarily, this is due to the historical experience with the software systems that exhibit larger numbers of errors than their other counterparts. However, the software itself cannot cause an accident; it becomes safety critical only when it is used to control potentially dangerous system. Formal methods, which are based on mathematical foundation, can be applied for modeling such systems giving