Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
Volume 3– No.8, December 2015 – www.caeaccess.org

Towards Self Sustainable Railway Transportation System!

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ABSTRACT
This paper is focused on numerous challenges holding by Railway Transportation systems and various techniques to solve problems. Scheduling is one of the challenges in Railway transportation system which depends on numerous constraints. This paper consists of discussion of deadlock free schedule using Agent based system and expert system for the railway transportation system to minimize overall system delay by considering other constrain depend on this. Despite having Persist enhancement in approaches still have limitations which require improvement to meet the objective of the entire railway transportation system.

General Terms
Scheduling, Railway Transportation system Issues, Problem Models.

Keywords
Scheduling, rescheduling, Railway Transportation system, Agents Based system

1. INTRODUCTION
Merchandise and passengers using the transportation system since long ago railway is one of them. The railway system management having four categories, which are strategic, tactical, operational and scheduling. There are two different aspects of any railway system which are Allocation & scheduling and Monitoring & Control. [5] Motivation behind this is increased demand in Railway transportation system holding numerous challenges in tactic railway operations may be scheduling, rescheduling, routing, energy optimization and other which are mentioned in the related work section. Multi agent based system consists of two layers regulating layer and learning layer one is to reschedule disrupted railway traffic with overall system delay constrain. While learning layer enhance the autonomy and intelligence of the whole system, when new disruption resolved by regulating layer learner agent receive message from every agent of regulating layer append prospective rule based if similar rule not found. Which can apply in scheduling, system control, conflict detection, signaling, load-balance and passenger convenience issue of railway transportation system. While Expert system solves problems such as expert tasks like Fault finding, design, manufacturing planning and more of engineering field that are normally solved by human experts. [73] Which concern with the Decision support system, intelligent transport system to deal with planning, control, maintenance, monitoring of the whole system. In the next section of existing method are mentioned Integer programming, mixed integer programming, petri nets, alternative graph, simulation model and other models as well as Expert system, agent based system used to solve numerous issue of railway transportation system. Limitation of existing methods to meet the objective of the railway transportation system are mentioned. Issues that need to solve for the resolution of human expert resolution are concluded at last.

2. RELATED WORK
This section consists of discuss related to some published research in this area of railway transportation system and literature that address issues of the railway transportation system.

Routing which considers as a strategic operational issue of railway transportation system addressed by an ant based Heuristic for the Railway travelling salesman problem to minimize overall travelling time of journey. Also for timetabling optimization of single and double track railway network. After that an efficient hybrid algorithm approach for to solve periodic single track train timetabling. After that MILP based approach for optimal train routing and scheduling for managing traffic perturbation in complex networks. [45] [46] [58] [71]

For energy efficiency of the railway transportation system In 2014 Su, Tang, Li, Gao proposed integrated algorithm for globally optimal operational schedule with better energy savings. [27] In 2013 Cardador, Cucala, Scire proposed energy regulation algorithm to get back train on schedule after delay in high speed train. [28] In 2013 Wu, Yan, Chen Proposed two algorithms for reduction of power consumption in wireless sensor network for railway disaster prevention and safety monitoring. [67]

For a tactic category operation like scheduling of railway transportation system in 1998 Jnaczura published thesis on Modelling and analysis of Railway network control logic using colored Petri nets. [76] In 2008 Tormos with another five proposed genetic algorithm for the train scheduling problem. [31] In 2011 Cleark proposed genetic algorithm with six others for Railway platform allocation. [57] In 2012 Bayhan with one other proposed simulation model approach for a feasible timetable generator framework for railway scheduling problem.[30] In 2013 Corman with other three proposed iterative optimization framework for railway schedule using alternative graph method. [29] In 2014 Ariano with three other proposed MILP based AGLIBRARY advanced technique for practical real time scheduling and evaluate applicability in railway. [35]

While In 2007 Tormos with four other proposed intelligent train scheduling on highly loaded network using a sequential algorithm and CSP approach.[32] In 2013 Zheng, Ling, Shi, Chen, Chen proposed hybrid biogeography based

optimization algorithm for railway wagon scheduling in emergency relief. [69]

For deadlock in railway scheduling. In 2003 Fanti proposed deadlock prevention method for railway network using monitors for colored petri nets. [60] Zarnay proposed model of deadlock state of railway station operation using colored Petri nets. [15] In 2011 Vincent van der Vlies published thesis on Rail Transport Risks and Urban Planning: Solving deadlock situations between urban planning and rail transport of hazardous materials in the Netherlands. [75] In 2014 Ferrari with two other proposed model checking approach for deadlock free train schedule for management of critical section. [11] In 2014 Ferrari with three other proposed model checking approach for deadlock avoidance in train scheduling. [16] In 2014 Li, sheu, Gao proposed conflict distribution prediction method heuristic method for deadlock analysis, prevention and train optimal travel mechanism in single track railway system. [17]

For scheduling with passenger convenience In 2009 Xie, Luo, Peng proposed approach for optimization of train operating schedules of high speed intercity train for passenger convenience. [49] In 2014 Mesa and other proposed rescheduling railway timetable in presence of passenger transfer in between lines within transportation network. [40] Rescheduling require in case of flood and other emergency [63]

For uncertainty and delay In 2014 Corman with other four proposed optimal train schedule using branch and bound, FIFO for disturbance and uncertainty management. In 2011 Canca and three other proposed MINLP approach for different objectives in the determination of train scheduling. [33] For the sensitivity of scheduling, in 2008 castillo with three other proposed bisection method based on timetabling optimization of a single track railway with sensitivity analysis. [42] In 2014 Abid and Khan proposed Branch and bound method for sensitivity analysis of the train schedule of the railway track network. [13]

In 2006 ingolotti with another five proposed new heuristic to solve constrained specification for planning scheduling and decision support. [43] In 2015 Jiang and other two proposed train timetable forming quality evaluation based on the data envelopment analysis approach. [47] In 2007 Liebchen and mohring proposed the modelling power of periodic event schedule problem for railway timetable and planning. [48]

For the conflict in schedule, in 2011 Wen proposed approach for train operations conflict management of the high speed Railway. [59] In 2012 corman with other 3 proposed alternative graph based approach for Bi-objective conflict detection and resolution in railway traffic management. [14] In 2013 Larsen proposed approach for sustainability of optimal train schedule for disturbances. [18]

Railway scheduling requires to address delay for this, in 2010 muralli with three proposed delay estimation technique for single and double track railway. [20] In 2010 Goverde proposed bucket based delay estimation algorithm for delay propagation in large scale railway traffic network. [21]

For dispatch, in 2010 corman published thesis for real time railway traffic management for dispatching in complex, large and busy railway network. [74] In 2012 Kraseman proposed effective algorithm for fast response to reschedule railway traffic during the disturbance. In 2014 corman and other three proposed heuristic algorithm for dispatching and coordination in multi area railway traffic management. [23] In 2013 corman with two other proposed Roma Egtran approach and framework for stability analysis of railway dispatching plans in a dynamic environment. [24] In 2015 Xu, li yang proposed approach based on discrete event model-DEM for scheduling heterogeneous traffic on double track with efficient dispatching rules. [25]

After discussing work related to scheduling next is related to work proposed, survey and reported related rescheduling. For rescheduling, in 2005 Nirio and two other proposed train rescheduling algorithm based on PERT and Meta heuristic approach for passenger convenience. [37]

In 2011 Narayanswami and Rangaraj proposed review of expository analysis of railway scheduling and rescheduling approach. [44] In 2012 Yang proposed approach for rescheduling train with scenario based fuzzy recovery time representation. [66] In 2014 Cacchiani with another six published overview of recovery models and algorithm for real time railway rescheduling. [36] While In 2013 Albrecht and lee proposed problem space search meta heuristic approach for rescheduling rail network with maintenance and disruption. [41]

In 2012 Fan and other two have compare brute force, FCFS, tabu search, Genetic algorithm, simulated annealing, ant colony optimization, decision tree elimination for minimizing delay cost in disturbed the railway traffic scenario. [22] In 2013 Aranda and Rodenas proposed demand based weighted train delay approach for rescheduling railway network in real time using an alternative graph method. [19]

In 2013 Dundar proposed train rescheduling using genetic algorithm and artificial neural network. [38] In 2014 Almodovar and Rodenas proposed two greedy heuristic approaches for online reschedule optimization for passenger in case of emergency. [39] In 2015 wei fang with two other published survey paper on rescheduling problem models and solution by models. [1]

While In 2013 bergmier with three other study use of machine learning methods for incident prediction in high speed train tracks. Decision support system, expert system and intelligent transport introduce to address numerous issues of railway transportation system. [65] For this In 2010 Zak published a chapter on decision support system in transportation. [61] In 2011 Corman with three other propose branch and bound based decision support system for optimal multi class rescheduling in the railway network. [34] In 1995 Larroche proposed a real time expert system that automates rail routes. [50] In 2006 tsamboulas and Mikroudis proposed Trans-pol which is decision support system and an expert system for the transportation system. [68] Ingoloti and four others have proposed a decision support system for railway scheduling problems. [26] In 2011 jiang and other two proposed sustainable strategies for railway intelligent transport system using Artificial intelligence. [55] In 2013 He, song and Chaudhary proposed service oriented intelligent group decision support system application in the transportation system. Li, Jia, Nie study railway intelligent transport system architecture. [56]

Up to now work related to routing, energy optimization, scheduling, rescheduling of the railway system by numerous methods as well as decision support system, expert system

and intelligent transportation system to address numerous issues of the railway transportation system. After that, work related to the railway transportation system issue using multi agent system. For this Mascardi with four other proposed the multi agent system for monitoring and diagnosis of railway signaling. [9] In 2004 proenca and oliveira proposed multi agent railway control system which consist of two layers: Regulating Layer and Learning Layer"Control" layer is responsible for traffic supervision, regulation, security and fluidity, including three distinct agent types: "Supervisor", "Train" and "Station". The "Learning" layer, using situations accumulated by the "Control" layer, will infer rules that can improve traffic control processes, minimizing waiting time and stop orders sent for each train. In this future conflicts are harder to solve. [6] In 2005 basra and three other proposed multi agent system to resolve scheduling issue of the London underground. [7]

In 2007 Zi-yu, lei proposed IDSS of high speed railway based on multi agent. [54] In 2008 Letia with other two proposed multi agent approach for distributed scheduling for real time railway traffic control. [51] Wang proposed agent based monitoring architecture for load balance in China train control system. [52] In 2010 sun with two other proposed multi agent based intelligent transport system for distributed hierarchical control for railway passenger dedicated line. [53]

In 2013 Ghosh with three other proposed multi agent system based simulation to improve Indian railway efficiency which consists of a Max-sum algorithm to minimize overall system delay and discuss six different cases where chance of conflict is possible at last they have discuss result comparison with max sum algorithm and without for delay parameter. [4] In 2014 Ankit Bhardwaj and two other proposed multi agent based train passing in railway system with minimum delay. [3]

In 2014 Anshul verma and pattnaik proposed mobile agent based train control system for mitigating meet conflict at the turnout. [8] In 2014 kuznetsov and three other proposed designs and optimization of algorithm for multi agent railway control system. [10] In 2015 Narayanswami and Rangaraj proposed multi agent system architecture for dynamic real time rescheduling and learning applied to railway transport. This paper has a multi agent based architecture for dynamic and real time rescheduling in case of conflict. A Multi agent system with 2 layers: Regulating layer which consists of four agents named train agent, supervisor agent, station agent, auctioneer agent and learning layer which having learner and facilitator as two different agents. Regulating layer control the conflict and learning layer generate or select a rule from rule based. [2]

3. DISCUSSION

There are several methods used to solve numerous issues and challenges of the railway transportation system which is categories into four different levels as per table I.

Table 1. Railway Operations Classification

Category	Operation
Strategic	Routing, energy efficiency
Tactic	Scheduling, traffic management
Real time control	Shunting, signaling
Operational	Maintenance planning

In table I name of the operation of various categories which are discussed in this paper there are many other operation names which fall under various category are not listed there in table.

3.1 Alternative Graph Model

Alternative graph model conflicts free schedule with minimum delay in real time network. Conflict occurs when two or more trains require same block at the same time. Alternative graph model consist of a set of nodes, set of fixed arc and set of pairs of alternative arcs with positive, null or negative length. In Alternative Graph model for one route, one arc selected from each pair of alternative arc and set of arc from alternative arc.

3.2 Discrete Event Model

For conflict resolution within time bound and recover schedule from delay in the railway transportation system the discrete event model with genetic algorithms (GAs), simulated annealing (SA), and tabu search (TS).

3.3 Mixed Integer Programming Model

Mixed integer programming model is the base for MILP and MINLP model from the operational research point of view. Which consist of arrival, departure time and delay as decision variables in railway scheduling problem. The Mixed Integer Non Linear Programming model not more in use as it considers the objective function and constraints of the model are nonlinear.

3.4 Petri Nets

Petri nets to model for Train dispatch decision that require experience and a set of IF-THEN based knowledge rules. Colored Petri nets and fuzzy Petri nets were modelled by Petri nets.

3.5 Simulation Model

To support real time dispatching in rescheduling to conflict resolution and also to forecast the future status of the railway transportation system simulation model used to represent components of the railway system network.

3.6 Expert System

Expert system used to solve complex problem of a system that can be solved by human experts with experience. This requires expert level knowledge of the system to address the challenges of the system. Expert system deal with highly diverse problems. User, knowledge and interface are three components of expert systems.

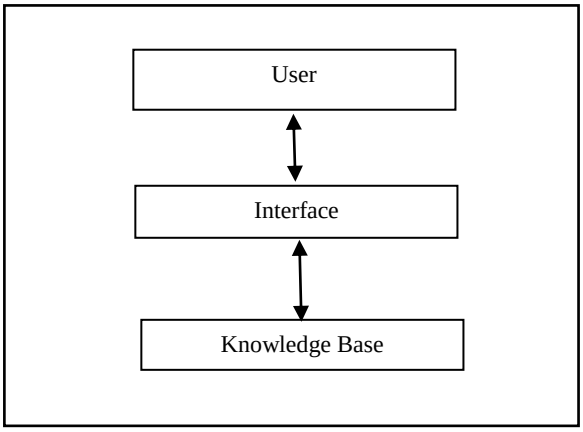

Figure 1. Component of Expert System [72]

3.7 Agent Based System

Agent based system consists of two layers in architecture which is regulating or control layer and the other is learning layer. Regulating or control layer consists of four agents in the layer, while learning layer consist of two agents leaner and facilitator. Supervisor remains active all time and sense disruption while auctioneer identifies conflicting trains for disruption and remain active until disruption solve. Train agent computes bids station agent verifies bids. When disruption solves rule updated to rule based and facilitator provides matching rule from the rule based on learning layer using Apriori algorithm of data mining. [2]

Table 2. Comparison of Problem Model

Model	Work	Objective
Discrete Event Model	Dynamic model, State of each instance at a time	Conflict Detection and Recover schedule from delay
Alternative Graph Model	Graph based Model with set of Arc, edge, vertices	Conflict schedule with minimum delay
Expert System	IF-THEN rule	Dispatch Decision, System control
Mixed Integer Programming Model	Binary, Non binary decision Variable	Rescheduling
Simulation Model	Computer based simulation from set of components	Simulation, Future conflict resolution, dispatching.

4. PROBLEM DESCRIPTION

The railway transportation system across the globe having very large passenger flow and other freight. Among that global railway Indian Railways (IR) is a great national asset. A single transport network connects far flung areas of the country. It is one of the largest transportation and logistics network of the World which runs 19,000 trains. It runs 12,000 trains to carry over 23 million passengers per day connecting about 8,000 stations spread across the sub-continent. It is equivalent to moving the entire population of Australia. It runs more than 7,000 freight trains per day carrying about 3 million tonnes of freight every day. Its network of 65,000 route kilometres is more than one and half times the circumference of the earth. The biggest challenge facing Indian Railways today is its inability to meet the demands of its customers, both freight and passenger.

Apart from the quantum of investment, quality of delivery is also an issue. Cleanliness, punctuality of services, safety, quality of terminals, capacity of trains, quality of food, security of passengers and ease of booking tickets are issues that need urgent attention. Indian Railways have a glorious past, a turbulent present and a bright future. It is a giant emerging out of a deep slumber. An awake, alive and kicking Indian Railways can lead the country to greater heights of accomplishment. However, today, it is mired in a state of ennui, a state of cynicism that things cannot change. Its network is congested and finances are not easy to come by. Resources for development and replacement are stressed. It is finding it difficult to even meet its operational expenses. But, the spirit is still alive. To make an attempt at resurrecting Itself, Indian Railways have drawn up an ambitious five year action plan. The realization is there that if the vicious cycle of underinvestment is to be turned into a virtuous cycle of prosperity; crutches of support will have to be abandoned.

The Indian Railways will have to generate its own resources for its development. The next five years should change the face of Indian Railways. Faster trains, modern trains, swanky stations, skilled staff, should be the Railways of tomorrow. IR looks forward to becoming the nation's carrier and a multi-modal integrator; making travel affordable, happy, convenient and reliable – a world class experience! IR also looks forward to becoming self-sustainable! [77]

5. CONCLUSION

From this discussion of railway transportation system conclusion made that from many years research work were proposed, survey and reviews were done and other report and thesis were published to address numerous challenges. Energy optimization, routing, scheduling- rescheduling with disruption handling, conflict detection and resolution, delay minimization, passenger convenience, uncertainty management, coordination management were addressed by existing methods which are a mixed integer programming model, alternative graph method, discrete event model, simulation model, Petri nets model, expert system and agent based system. As mentioned in previous section challenges that need to address are of resource allocation and management, applicability in large and congested network, passenger convenience.

Which require to resolve human expert resolution to meet the objective of the railway transportation system of India as well as applicable to the global railway transportation system also. Integration of approached used in existing methods can address some of the challenges of Indian railway which can be applied to other country also. If consider issues in the scheduling the required system that will address challenges like deadlock free schedule with a minimum system delay, expert dispatching and coordination to resolve conflict detection and accidents as well as applied in real time highly

congested network for single as well as double track as per types of trains.

For emergency or in disruption situation this schedule requires reschedule that restores schedule of the system. Coordination with last train fault diagnosis require in this. [62], [64] Expert system addressing complex problems of a system which help in decision support system as well as in intelligent system. While multi agent system address problem of dynamic disruption for scheduling- rescheduling as well as control system, delay minimization, conflict, signaling, load balance and passenger convenience.

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