A SMART RAILWAY SYSTEM WITH HYBRID ARCHITECTURE FOR POWER FLOW OPTIMIZATION

A Project Report

Submitted by
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THESIS CERTIFICATE

This is to certify that the thesis entitled " **A SMART RAILWAY SYSTEM WITH HYBRID ARCHITECTURE FOR POWER FLOW OPTIMIZATION**" submitted by **PREETHI.C.C, EE16M074** to the **Indian Institute of Technology Madras** in partial fulfilment of the requirements for the award of the degree in **Master of Technology** in Power System and Power Electronics is a bonafide record of project work by her under my supervision. The contents of this thesis, in full or in parts, have not been submitted and neither will be submitted to any other Institute or University for the award of any degree or diploma.

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ABSRACT

This thesis discuss a part of load flow analysis of Rail Distribution Power System how railway system is converted to a smart system.

In India, Railway the modern railway system is a massive grid connected complex system with distributed active loads(particularly distributed renewable sources) and storage(wayside or onboard energy storage systems).Its energy management therefore requires concepts and techniques similar to that of smart grid system.

The new architecture is proposed such as to integrate on-board, wayside and coordination services to achive optimal energy storage. The new Railway energy management system(REM-S) architecture is conceptualized and developed based on SG architecture model framework.

Previous projects such as MODURBAN, OSIRIS and MERLIN has been referred for understanding the REM-S architecture.

Table of Contents

CHAPTER-1
INTRODUCTION

The objective of this thesis is to optimize power demand of operating the railway system ensuring the fulfillment of the applicable perfor-mance requirements, reduction of power demand during power peak and reduce the global energy bill and limit or avoid financial penalties, reduce consumption.It also helps in developing a better purchasing strategy.

1.1 Background

In the automation architecture, each subnetwork is in contact with the control center and through it with the electricity market via Intelligent Electronic Device. The control center sends request or suggestions to the subnetworks (Border area energy issues are to be controlled). Each subnetwork is automated by the MultiAgent system(MAS) technology.

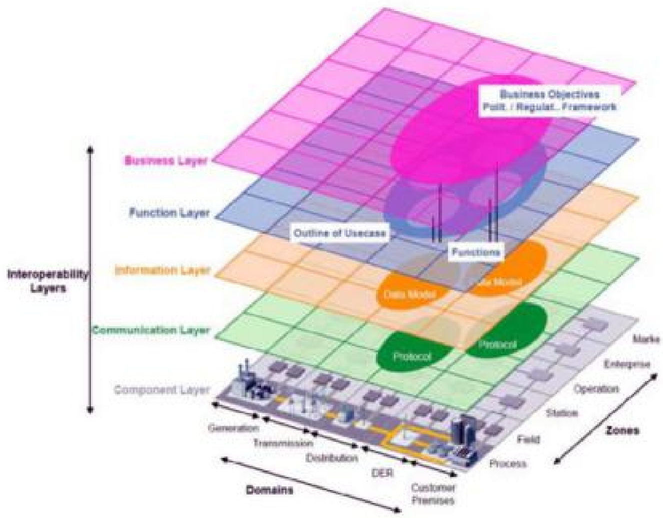
1.2 Subnetwork

Each subnetwork consists of an Intelligent substation in communication with all the energy components to send or receive commands. Each energy component has an intelligent entity awhich acts as an agent, which can make its own decisions. Reversible and non-reversible substations connected to the public grid acts as fixed agents in negotiation with the main agent. Wayside energy storage systems, Renewable sources are considered as the fixed agents.

Dynamic on-board energy managers are considered as moving agent.They are in contact with intelligent substation and are responsible for energy management inside the train. Workshops,stations or EV charging stations are considered as fixed agents.

1.3 SGAM Framework

The existing SG standards, communication protocols and ICT technologies are suitable for designing the hybrid architecture. It incorporates different time zones. The model for data management in control center is studied at 3 different time window modes. To achieve new business objectives , SGAM framework is applied. It has 5 interoperable layers such as business, function, information, communication and component.



SGAM framework

CHAPTER- 2
System Configuration and Literature Review

2.1 System Configuration:

The operational modes are,

1. Day Ahead Optimization(DAO):

Calculates the optimum behavior of the network like power profile, energy/power purchase, power sale for the next 24 hrs. A global EMS runs for the whole system and it uses a Top-Bottom approach on train timetables and profiles.

2. Minutes Ahead Optimization(MAO):

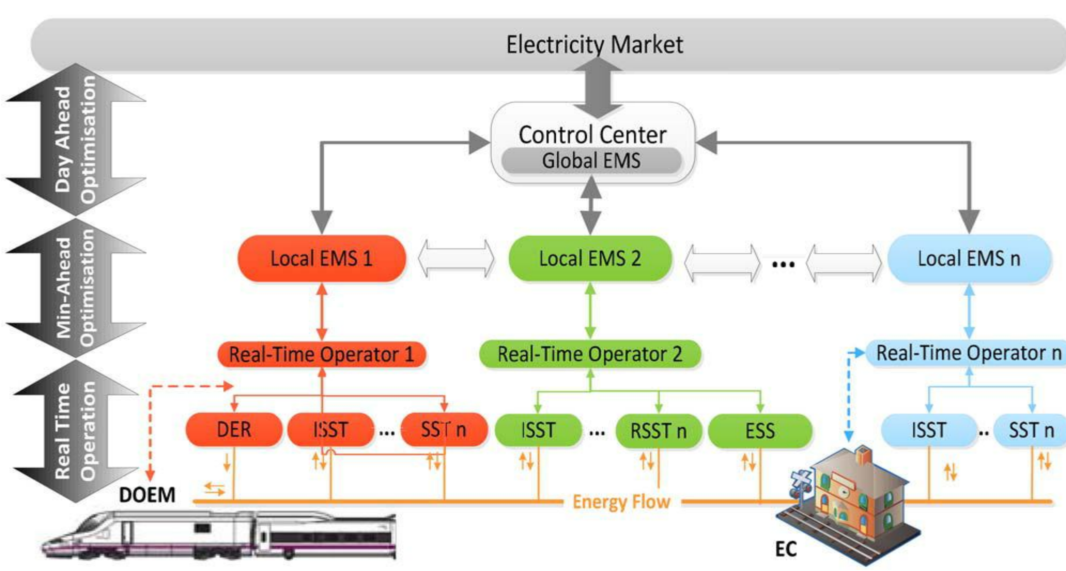
Locally predicts for the next 15 minutes. It covers all the subnetwork agents interaction considering power restrictions, surpluses. A local EMS executes in the subnetwork with target from the global EMS. It accomodates unexpected source requirement or load shedding.

3. Real Time Operation(RTO):

Fulfills the calculated MAO profile considering the real-time status and behavior of the components. It is the decentralized component.

These modes also take into account the location of the train.

2.2 REM-S Automation architecture and network modelling



DAO and MAO requires power flow calculation. Since train is moving in nature, a simple model must be considered.

2.2.1. Electrical network model

The substations are modelled as ideal voltage sources in series with equivalent impedance. Impedance of the overhead line and catenary are considered in series and are modelled as a single impedance representing the feeding section. Line is modelled as pi-line model. Loads except trains are modelled as constant power loads. Trains are modelled as constant current sources. Train power profile and its location are inputs for power flow calculation. Effect of train movement is represented by changing feeder impedance.

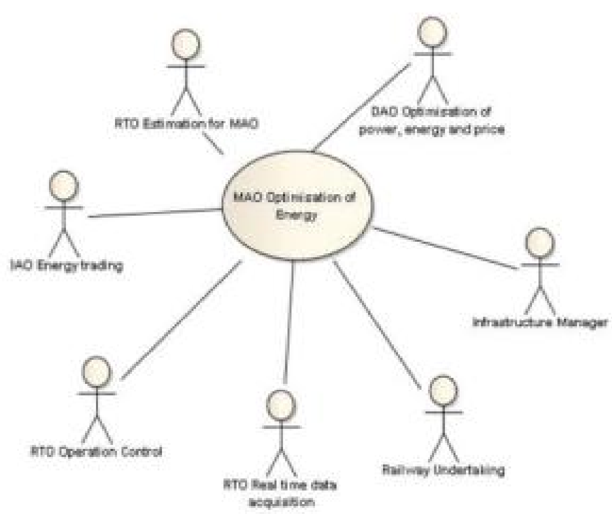
2.2.2 REM-S Analysis phase

Use case Analysis:

HLUCs are general use case actions or functions for energy trading, biling and global optimization. Energy trading is to buy and sell energy at the best price.biling calculates the real cost of the energy consumed and to optimize the operation cost. High level optimization is done centrally.

Constraints for HLUC:

Train should reach its destination with an allowable delay based on the railway undertaking, maximum utilization of the energy sources, limit infrastructure use.



Use Case Diagram

2.2.3 HLUCs and their function

Use Case Cluster	HLUC	Primary function
DAO	Optimization	Forecast ECs power demand
		Forecast power generation
		Forecasted of trains power profile
		Global optimization
		Audit with IM and RU
		Mapping scheduling to subnetwork consumption
		Reporting
		Deviation Alert_MAO
	Energy trading	Energy trading Estimation
		Energy trading
	Billing	Billing
MAO	Optimization	Day ahead profile slicing
		Supervision
		Local optimization
		Power mismatch calculation per subnetwork
		Negotiating among neighbour subnetworks
		Deviation alert_RTO
RTO	Real Time Data acquisition	Real Time Data acquisition for MAO
		Real Time Data acquisition for RTO
		Consumption measuring
	Estimation	Estimation for MAO
		Forecast aggregation
	Operation Control	Control
	Actions Implementation	Implementation of the suggestions

2.3 Literature review

The function of different SGAM layers are analysed and understood their importance. Expecting to generate an XML file for the data collected and to use this as a lookup in Extensive architecture software for further simulating the model. The process involves mapping railway system to SG architecture, harmonizing the SG standards in energy management and also expecting to incorporate hybrid vehicle for energy management.

2.4 References

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