Multi-agent Based Charges subsystem for Supply Chain Logistics

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Abstract—The main objective of this paper is to design charges subsystem using multi agent technology which deals with calculation, accrual and collection of various charges levied at the goods in a supply chain Logistics. Accrual of various charges such as freight, demurrage, and wharfage take place implicitly in the SC system at the various events of different subsystems which is collected and calculated by software agents. An Agent-based modeling is an approach based on the idea that a system is composed of decentralized individual 'agents' and that each agent interacts with other agents according to its localized knowledge. Our aim is to design a flexible architecture that can deal with next generation supply chain problems based on a multi-agent architecture. In this article, a multi agent system has been developed to calculate charges levied at various stages on good sheds.. Each entity is modeled as one agent and their coordination lead to control inventories and minimize the total cost of SC by sharing information and forecasting knowledge and using negotiation mechanism.

Keywords-Multi agent, Chages, Lumpsum Accounts, ARF, Wharfage

I. INTRODUCTION

In recent years, a new software architecture for managing the supply chain at the tactical and operational levels has emerged. It views the supply chain as composed of a set of intelligent (software) agents, each responsible for one or more activities in the supply chain and each interacting with other agents in planning and executing their responsibilities. An agent is an autonomous, goal-oriented software process that operates asynchronously, communicating and coordinating with other agents as needed.

Agent technology (Weiss, 1999; Wooldridge, 2002) aims to provide new concepts and abstractions to facilitate the design and implementation of systems of this kind. Parunak (1999) lists the following characteristics for an ideal application of agent technology:

• Modular, in the sense that each entity has a well-defined set of state variables that is distinct from those of its environment and that the interface to the environment can be clearly identified.
• Decentralized, in the sense that the application can be decomposed into stand-alone software processes capable of performing useful tasks without continuous direction from some other software process.
• Changeable, in the sense that the structure of the application may change quickly and frequently.
• Ill-structured, in the sense that all information about the application is not available when the system is being designed.
• Complex, in the sense that the system exhibits a large number of different behaviors which may interact in sophisticated ways.

These characteristics closely resembles the agents behavior in SC Logistics. Each agent acts based on its internal model of that particular activity and interacts with other agents in the network. In order to execute a particular operation in Logistics, agents not only interact with each other, but they also share information and negotiate and coordinate with each other which leads to improvement in delivery performance and inventory reduction and calculation of various charges levied at the goods in a supply chain Logistics

II. MULTI-AGENT BASED CHARHES SUBSYSTEM FRAMEWORK

This sub module acts as an input for accounting agent. Here various charges are collected and waived using this sub module. Here is the list of functions that are carried using different agents cooperating and interacting with each other in order to achieve its final goal.

List of Functions
- Maintenance of Lumpsum Accounts
- ARF Calculation
- ARF Forfeiture
- ARF Refund
- Basic Freight Calculation
- Demurrage Calculation and Collection
- Wharfage Calculation and Collection
- Local Charges Accrual and Collection
- Collections against MR
- Bill Generation and Collection

Figure1. Charges Subsystem DFD
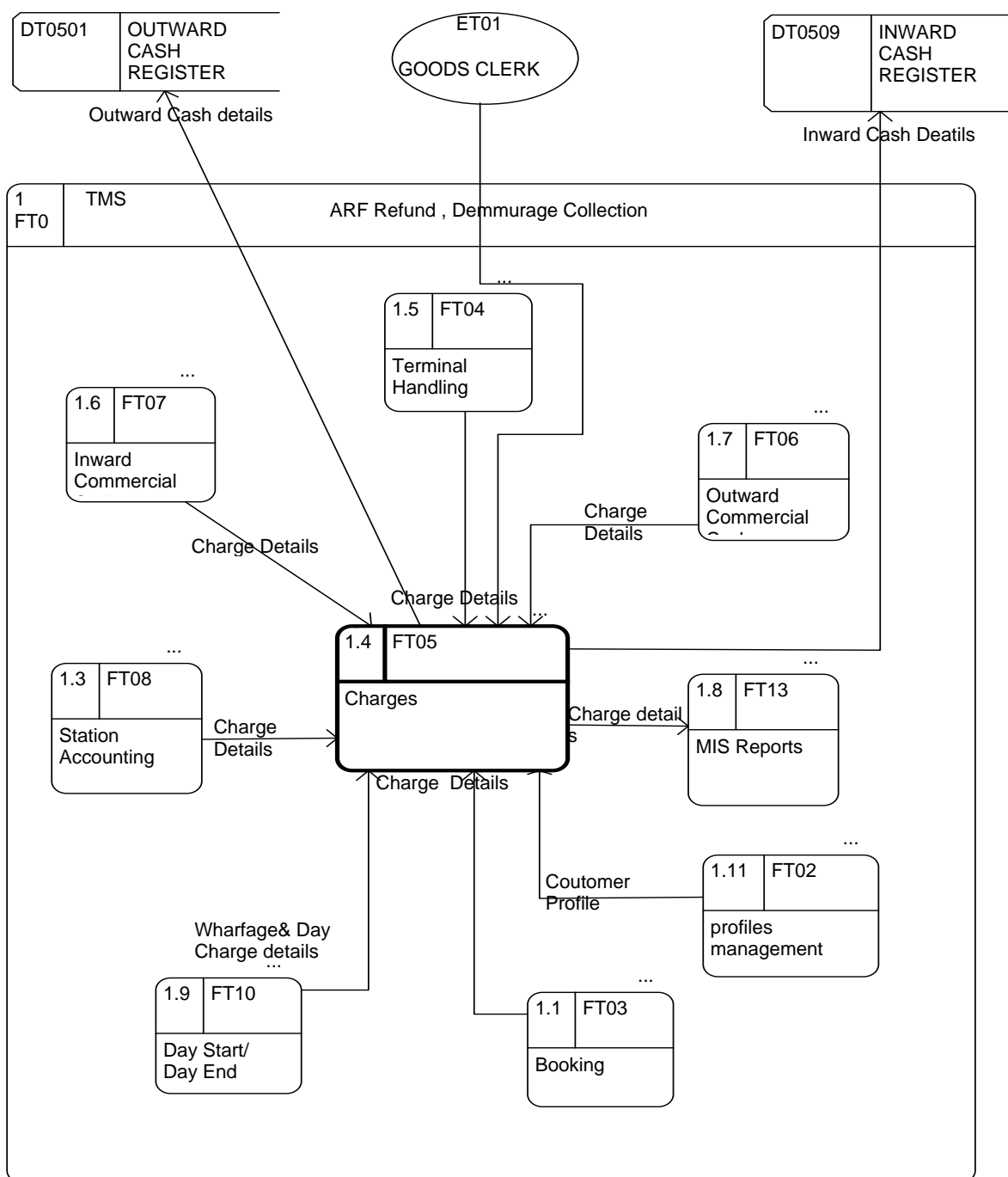
Assumptions

- System shall not re-calculate any charge with retrospective effect.
- All the calculations shall be for the event date. System shall not calculate charges for the future date or back date.
- All the collections shall be for the event date.
- The codified fields like station, customer, cargo type and commodity shall be validated from the master tables.
- Money receipt number shall not be generated or validated by the system.

Maintenance of Lumpsum Accounts:

Lumpsum account is customer's monetary account maintained at the goods shed by Lumpsum service agent. These accounts are created for permanent customers with recurring business at the goods shed. Lumpsum agent uses Lumpsum accounts to facilitate financial transactions by allowing goods shed to credit/debit the customer's account when any given charge is to be refunded/collected. Customer can get the details of transactions on his account for a specified period.

Lumpsum Service agent maintains Lumpsum accounts customer-wise. A Lumpsum agent maintains different accounts for ARF, freight and sundry charges. Lumpsum Accounts are used by customer agent for making the payments of ARF, Freight and Sundry charges to the 3PL. Each Lumpsum account shall maintain a specified minimum balance.

A Lumpsum agent, at any given station, can have following types of Lumpsum accounts:

- ARF Account
- Freight Account
- Sundry charges Account

Here agent would be responsible to carry out following operations:

- Creating new accounts / Entry of existing Lumpsum accounts
- Replenishing a Lumpsum account
- Balance Query
- Modifying Lumpsum A/C minimum balance
- Printing of Statement of Account

Validations and Checks carried by the Agent:

Money Receipt date should be a valid date.

No transactions are allowed where the minimum balance of the Lumpsum account is less than the minimum balance specified.

Lumpsum account balance to be reset to zero on day end of last day of month of Lumpsum accounts where carry forward flag is 'NO'

Payment for balance of Lumpsum account can only be done through MR agent. In case of Lumpsum account with carry forward 'No', at the time of debit from the account, the debit date should be less than or equal to the valid up to date. No replenishment of such account, in new month, shall be permitted till the last date of the previous month is closed.

ARF Calculation:

Advanced Registration Fee (ARF) is the security amount deposited at the time of submission of forwarding note. ARF agent calculates depending upon whether Demand is Rake/Cargo or Piecemeal demand. The ARF is calculated per wagon in the case of piecemeal demand

Rake ARF shall depend on type of customer (Government / Non Government) which is collected from customer profile. Here ARF agent communicate and coordinate with Lumpsum agent to get customer type.

ARF is calculated as:

For rake :   Fixed amount

For piecemeal: Number of units * rate of ARF

Validations and Checks
- If ARF is not to be collected as per the customer profile, no ARF amount shall be calculated and accrued by the agent.
- Also ARF agent shall not accrue any Fee for traffic booked on Military Credit Note

ARF Forfeiture:

When a customer agent withdraws his demand fully or partially within a specified time or after allotment, ARF agent shall not refund back to him if ARF is already collected. This is called forfeiture of the ARF amount which is another function of ARF agent.

Validations and Checks
ARF agent ensures that Amount forfeited shall always be less than or equal to total ARF amount collected

ARF Refund

ARF agent refunds amount in following situations:

Customer agent completes the Loading
Customer agent withdraws the demand as 3PL is not able to supply the wagons within the specified period

Validation and Checks
Refund shall be invoked after Invoice generation.
Refund shall be invoked if the 3PL fail to supply the wagons within specified days after registration of Forwarding Note.
ARF to be refunded only to forwarding notes from which ARF was collected.
Cases where ARF amount was collected through MR, ARF refund shall be allowed only when MR number and date input in the task is same as the one through which ARF collection was done.

Basic Freight Calculation
   Basic Freight is the amount charged by 3PL for transporting consignment from originating to destination station. It depends on distance traveled, type of commodity, rate type and weight loaded. Along with Basic Freight system calculates surcharges such as 'Punitive Over Load (POL)', 'To Pay Surcharge (TP)', 'Percentage Charge'. Agent collects these all information from DB master table in order to calculate Freight.

   Total Freight = (Basic Freight – Percentage Rebate) + POL Freight
   Total Chargeable Freight = (Total Freight + Percentage Surcharge on Total Freight)

Demurrage Calculation

   The delay in loading or unloading, as the case may be, after a specified free time, causes levy of demurrage charges from the Lumpsum agent (consignor or consignee respectively). Demurrage calculation in both Inward and Outward Cycle shall be invoked from DEMURRAGE COLLECTION agent. Demurrage Collection agent also collect outstanding Demurrage charges. This agent displays the wagon-wise Demurrage accrual details. Outstanding demurrage charges can be waived in part or full by a competent authority.

   Total Demurrage amount outstanding is calculated as:

Total Demurrage Accrued – (Total Demurrage Waived + Total Amount Credited)

Collections of the demurrage can be done by any one of following modes:
- MR
- Bill
   Lumpsum account

Wharfage Calculation:

   Space allotted by 3PL to the customer agent to facilitate his loading/unloading is called Wharfage. Any delay by customer agent in carrying out loading/unloading and blocking space at wharf for subsequent use invites penalty charge on the customer called Wharfage charge. Agent is not only responsible to calculate Wharfage but also responsible to collect outstanding Wharfage charges. This agent displays the lot-wise Wharfage accrual details. Outstanding Wharfage charges can be waived in part or full by a competent authority

Validations and Checks
- Collection of wharfage cannot be done until wharfage amount has been accrued.
- Payment by Lumpsum account shall be allowed only in cases where the Consignor maintains a Lumpsum Account for Sundry charges at the Station.
- Payment by bill allowed only for permanent customers with recurring business.

Local Charge Accrual:

All the miscellaneous charges like handling, crane, siding, shunting, repositioning, land lease, unloading charges, and diversion fees, terminal tax and some local unforeseen charges that are applicable to an invoice or customer are called Local Charges. This agent captures the Local Charges details as well as its collection details.

Collection of Local Charges, like their accrual, fall in one of three categories:
- Against Invoice (for consignments of inward traffic)
- Against forwarding note (for consignments of outward traffic)
- Customers.

Collections against Money Receipt:

Money receipt (MR) is a document given by 3PL in acknowledgment of the amount received from the customer. This document acts as proof of having made payment for the customer.

MR is given for payments made through Draft, Cash, Cheque, and Credit Note cum Cheque, Govt. Credit Note, Military Credit Note, and Civil Credit Note.

Validations and Checks

- Collections by MR shall be invoked only when mode of payment is 'MR'.
- The total amount of all the instruments should be equal to the outstanding amount

Bill Generation:
The generation of bill is done only for permanent customers with recurring business. Customers eligible for bill payments can only defer their payments using bill payment to a later date. To generate bill, user shall enter the customer code and the period for which outstanding for that customer needs to be cleared.

Validations and Checks

- Only charges marked for bill payment for customer for given period are displayed.
- Bill number shall be unique and is generated by the system.
- The period for which bill is being generated should be from the date last charge for that customer was settled by bill.

Assumptions and Dependencies

- Bill is generated separately against different charges.
- A single bill can be generated for multiple invoices for the same customer and same charge type.
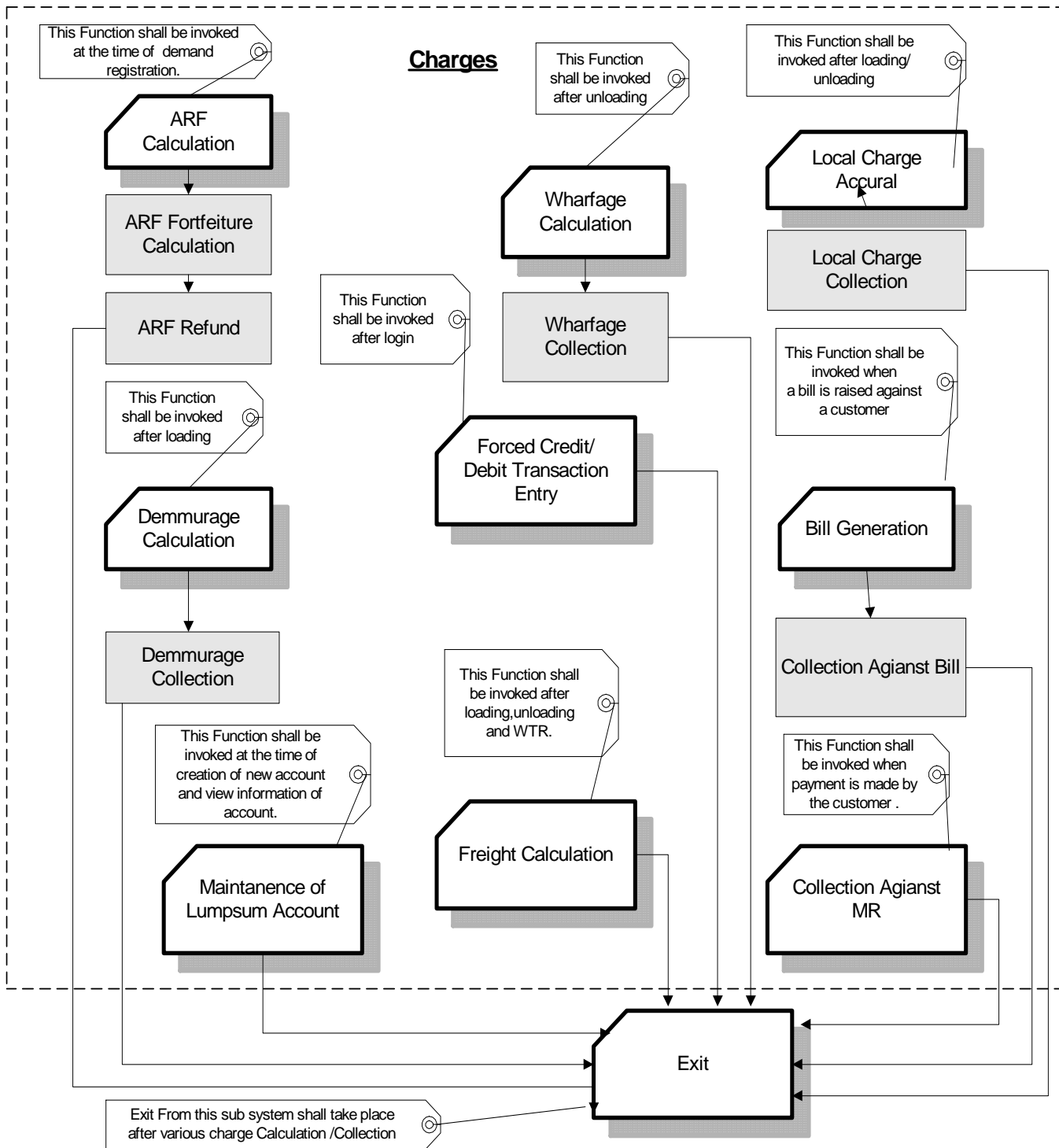
Figure 2. Functional Hierarchy Diagram

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