Chapter 7
Applications of Predictive Computing

7.1 Introduction

Predictive computing is used in a wide spectrum of real-world problems ranging from business, government, economics and also science. Some major fields reaping the advantages of predictive computing are financial services, insurance, telecommunications, retail, healthcare and government [1]. Predictive computing is now adopted by almost all major work sectors as its advantages are evident in every field. Predictive computing helps in knowing the customers and acts on the insights provided by the predictive analytics on future customer behaviour. This can help to identify the best actions to take for every customer or transaction [2] and help in guiding other strategic actions to be taken for the profit of business, such as collaborating with agencies that maximize the profit in the approved budget, or detecting frauds or abuse in insurance or healthcare claims. It can help in answering complex questions such as live transactions, with empirical precision at incredible speeds [2]. Decisions that earlier took hours or days, can now be taken in milliseconds. Insights given by analytics can be helpful as they can reduce the business losses by accurately measuring the risks and frauds. Predictive computing can detect the slightest abnormality in a pattern of usual business routine transaction or data, and hence can help reduce business losses. Predictive computing adds consistency and stability to business decisions and in turn improves customer service as it relies on mathematical models and techniques. Also, the decisions provided by predictive analytics are consistent and unbiased as compared to human experts. Predictive computing is a requirement of today's world as everyone needs consistent, faster, smarter decisions to meet the agile business standards, where market conditions change quickly and frequently. Also, it is required to improve the customer service and grow the profit of the business. Predictive computing improves every aspect of decision-making process, which includes: precision, consistency, agility, speed and cost [2]. There are uncountable applications of predictive computing in business intelligence, and this is because of the fact that predictive

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computing has reached the roots of various business sectors. Predictive computing allows us to anticipate the future and make an optimal decision by extracting information from the datasets, which in turn helps to discover complex relationships, recognize unknown patterns, forecasting actual trends, etc. [3].

7.2 Applications Based Features of Predictive Computing

Considering the various horizons for predictive computing as presented in Table 1.2 of Chap. 1, we have selected three application-based scenarios, i.e., smart mobility, e-Health and e-Logistics to be presented in this chapter. Each scenario consists of various applications, where predictive computing can be successfully implemented. Following sections discuss about these applications.

7.2.1 Smart Mobility

Urbanization of the cities of developing countries has led to a steady rise in the number of vehicle registrations, traffic congestion problems, heavy fuel demands and fuel consumption, and financial and economic challenges. In the past several years, smart mobility (e-mobility) has been a subject of intensive research and discussion revolving around ecological and economic arguments around the world [4]. Among the varied discussions, countries like Singapore, China, Japan, India and South Korea, have presented interesting approaches while promoting and implementing smart mobility. Key factors driving smart mobility among others are smart vehicle navigation, finding optimized shortest paths, smart technological capabilities of the vehicle to reduce fuel consumption. Smart mobility can be sought out as a solution to congestion, increasing air pollution, noise pollution in the cities of developing countries. Smart mobility can be considered for addressing these problems as well. In [5], Pattanaik et al. have proposed a *smart congestion avoidance technique* by estimating the scope of real-time traffic congestion on urban road networks which also *predicts an alternate shortest route to the destination* as shown in Algorithm 7.1. The proposed system uses *k-Means clustering algorithm* to estimate the magnitude of congestion on different roads, later it employs *minimum spanning tree algorithm; Dijkstra's algorithm* to predict the shortest route. Once the system receives the user's destination coordinates, it predicts the shortest route from the user's current location. This process is reiterated until the user reaches the desired destination. The proposed methodology can predict which road segments are congested or clear through the real-time GPS data and inform the user about real-time traffic conditions and adjusts the route so as to avoid congestions and reduce travelling time. The congestion avoidance algorithm is given below.

Algorithm 7.1: Congestion Avoidance Algorithm [5]

1. Fetch Driver's Current Location (Source)
2. Get Destination Coordinates
3. Retrieve Road Map of Area
4. **while** *Source* $\neq$ *Destination* **do**
5. Retrieve Real-Time Traffic Data from App
6. Plot Traffic Data onto 2D Problem Space
7. Apply *k-Means Clustering* on Traffic Data
8. Assign Weights to Traffic Clusters
9. Combine Traffic Cluster Data with Road Map
10. Convert Weighted Road Map into Neighborhood Matrix
11. Apply *Dijkstra's Algorithm*
12. Display Shortest Path
13. Fetch Driver's Current Location (Source) Again
14. **end while**

In another work, Milojevic and Rakocevic [6] have presented that vehicular traffic congestion is becoming a major economic and social problem which requires the government's utmost attention. It leads to significant financial and safety challenges, and also a major contributor to the increasing pollution in the cities. They have proposed a new vehicle-to-vehicle (V2V) congestion detection algorithm based on the IEEE 802.11p standard. This algorithm allows vehicles to be self-aware about road conditions and finds congestion detection based on the monitoring of speed and cooperation with the surrounding vehicles. Proposed algorithm comprises of five steps as shown in Algorithm 7.2, (1) *Speed Monitoring*, (2) *Congestion Detection*, (3) *Localization*, (4) *Aggregation* and (5) *Broadcasting*. They have also presented a performance evaluation using large-scale simulation in Veins framework based on the OMNet++ network simulator and SUMO vehicular mobility simulator. Results show that precise congestion detection and qualification can be achieved using a significantly decreased number of exchanged packets.

Algorithm 7.2: Congestion Control Algorithm [6]

1) Speed Monitoring
  IF $V_c \neq V_t$ **GOTO** 2;
2) Congestion Detection
  IF $V_c < V_t$ **THEN**
    (Start Timer τ_c, WHEN $\tau_c = \eta.10s \Rightarrow C_p = \eta$);
  ELSE (Start Timer τ_c, WHEN $\tau_c = 10s \Rightarrow C_p = 0$);
3) Localization
  FIND A_{id} of the current location, **GOTO** 4;
4) Aggregation
  GET $C_d(A_{id})$;
  IF ($C_p \neq 0$) **THEN**
    IF $C_p(A_{id}) > C_d(A_{id})$ **THEN** 5, $C_d(A_{id}) = C_p(A_{id})$;
    ELSE skip 5;
  ELSE IF $C_p(A_{id}) \neq C_d(A_{id})$ **THEN** 5, $C_d(A_{id}) = C_p(A_{id})$ **THEN** 5;
  ELSE skip 5;
5) Broadcasting
  Broadcast the (C_p, A_{id});

In [7], Abhishek et al. have presented a study to analyse and resolve the congestion of the complex traffic conditions in the cities. Proposed algorithm tries to control and optimise the duration of time for which the traffic light signal is green, and the number of vehicles passing through the junction during that time period. Wireless sensor network has been used to make the traffic signals adaptive to the dynamic traffic flow, so that the number of vehicles passing through the signal is maximized. Following parameters have been considered while the development of proposed algorithm: (1) *Waiting Time*, (2) *Clearance Time*, (3) *Rate of Arrival*, (4) *Proportionality Constant*, (5) *Clear Route* and (6) *Multiplication Factor*. In [8], a new smart traffic control design is presented which resolves traffic issues and utilizes available road infrastructure. Authors have also considered reducing the waiting time, fuel consumption, traffic congestion and levels of traffic obstruction. Intelligent Traffic Control System (ITSC) is based on a principle stated as ‘a car can only move ahead if there is space for it to move ahead’ and ‘the signal remains green until the present cars have passed’. Here, sensors are placed at every entry and exit of a junction, and are responsible for monitoring the number of cars present at the junction to make traffic management smooth and efficient. Ye et al. [9] and Malekian et al. [10] have proposed driving route prediction methods based on the *Hidden Markov Model* (*HMM*). This method can accurately predict a vehicle’s entire route as early in a trip’s lifetime as possible without inputting origins and destinations beforehand. First, the driving route recommendation system architecture is proposed which highlights a method for route prediction based on the

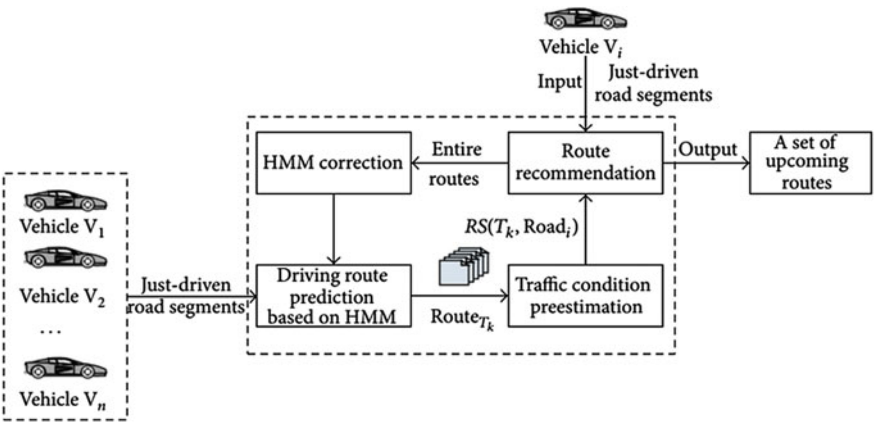

Fig. 7.1 Architecture of route recommendation system [9]

knowledge of HMM. The method can predict the congested road segments as well as smooth road segments through route prediction. The system also updates traffic information in real time and informs the driver to adjust the driving route as the trip progresses. Figure 7.1 shows the architecture of the proposed driving route recommendation system.

This architecture consists of four phases; (1) *Driving Route Predictions Based on HMM*, (2) *Traffic Congestion Pre-estimation*, (3) *Vehicle Route Recommendation* and (4) *HMM Correction* for route prediction and recommendation. Table 7.1 summarizes various applications designed and used for smart mobility of vehicles.

7.2.2 e-Health

Healthcare is another major sector that has witnessed the wide use of wireless sensor networks, IoT, and Cloud computing to perform various types of predictions related to patient's health, monitoring of blood pressure, heart beats, breast cancer, lung disease, etc. Diagnosing from early symptoms or patterns, predictive computing can be used at each level of e-Health-related applications. Health applications designed and used previously, have been shifted to e-Health [30]. Earlier, medical applications were based on the analog telephony that enables the individuals to call the healthcare professional, hospitals to take appointments, and to transmit electrocardiograms over telephone lines [30]. Tele-Health involves health services delivered from a distance and is an important constituent of e-Health [31], but these analog techniques could not be expanded due to the bandwidth limitations, low rate of data transfer over copper wires, the existence of inference and noise. Another constituent of e-Health is 'm-health' which can be defined as a medical and public health practice supported by mobile devices, such as mobile phones, patients monitoring devices and other wireless devices [32].

Table 7.1 Applications for smart mobility

S. no.	Application	Purpose
1	Smart real-time traffic congestion estimation [5]	An intelligent system that predicts congested road segments through real-time GPS data, and suggests shortest alternate route
2	Distributed vehicular traffic congestion detection algorithm [6]	A system that uses a new vehicle-to-vehicle (V2V) congestion detection algorithm which allows the vehicle to be smart. It allows vehicles to be self-aware of the traffic on the road based on the speed analysis and assistance with neighbouring vehicles
3	City traffic congestion control [7]	A wireless sensor network used to analyze and resolve the congestion of the complex traffic conditions in the cities
4	Smart navigation for visually impaired [11–14]	An intelligent, portable, and user-friendly system that enables the visually impaired people to navigate in an environment without any human intervention. It provides assistance for both indoor and outdoor navigation by voice input and output
5	Modelling urban traffic dynamics [15]	A smart system that proposes a way to capture the complexity based on generalization power of Markov chains in coexistence with continuous urban data streams
6	Remote monitoring of vehicle diagnostics [16]	A distributed system that is used for remote monitoring of vehicles and their geographical position using a smart box with GPS and GPRS
7	Intelligent traffic control system [8, 17]	A smart traffic control design that resolves traffic issues and utilizes 100% use of the road infrastructure
8	Route predictions based on hidden Markov model [9]	A system based on the HMM that can accurately predict a vehicle's entire route at the earliest in a trip's lifetime
9	Vehicle tracking system using IoT [18–20]	An intelligent system that makes use of built-in internet enabled GPS sensor to render a real-time and reliable vehicle tracking services to public
10	Intelligent ambulance using IoT [21]	An intelligent system that proposes to make way for ambulances in heavy traffic congestion traffic situations by manipulating the timer of the signal light board
11	Smart parking system using IoT [22–25]	A smart parking system that enables the user to identify the closest parking area and provides the availability of vacant parking slot in the current or neighbouring area
12	Improvement of traffic monitoring system using IoT [26]	An adaptive traffic congestion control system that provides time slot to each route based on the traffic density by fetching the location and

(continued)

Table 7.1 (continued)

S. no.	Application	Purpose
		speed of the vehicle using GPS, which in turns enables us to calculate the accurate time when the vehicle reaches the next intersection
13	IoT-RFID testbed for supporting traffic light control [27]	An IoT-based application for traffic management system that enables the traffic police officers in support decision making
14	Framework for agent-based traffic light control [28]	A smart agent-based framework that proposes a balanced, coordinated and optimal method for traffic light control
15	Real time traffic congestion detection system [29]	An intelligent system that detects real-time congestion without any human intervention or human supervision without any prior knowledge about the condition

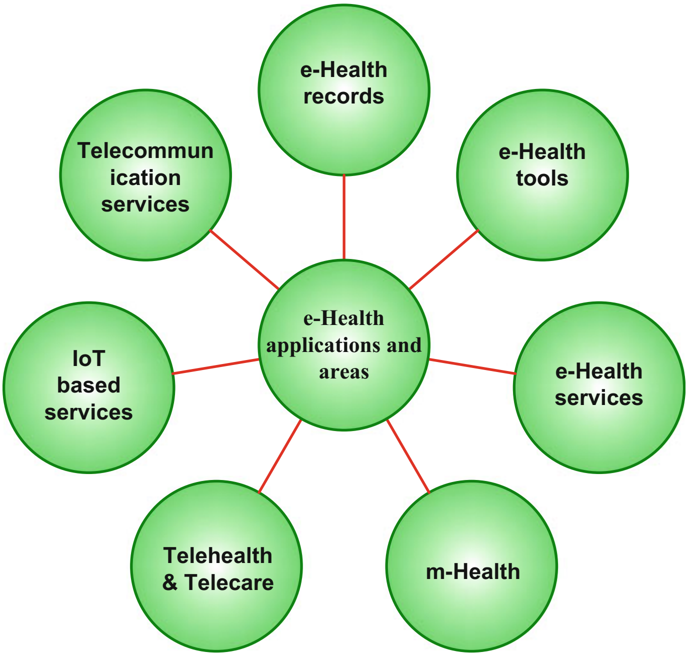

Fig. 7.2 e-Health applications and its target areas

e-Health has become part of every citizen's everyday lives and impacts them in one way or other, and this has led to the development of various e-Health related applications. e-Health applications use the information and communication technologies (ICT) for handling various health-related services. It deals with the broad spectrum of e-Health policies, legal and ethical frameworks, adequate funding and training [33]. The target areas of e-Health are depicted in Fig. 7.2. It has seen a tremendous growth over the past 30 years, enabling the exchange of healthcare and administrative data and transfer of medical images and laboratory results [30].

In [34], Gupta et al. have discussed an IoT-based cloud-centric healthcare architecture predictive analysis of physical activities of the users in sustainable health centers. The prerequisite of this framework is that health centres should be well equipped with sensors for capturing the patient's basic health parameters while exercising, such as heart rate, distance, speed, and calories burned daily by a user. These parameter values are stored at the end of the session using either a public or private cloud. Next, the healthcare personnel can access this stored information when required. An alert is sent automatically to the healthcare personnel, if any irregularity is predicted in the user's activity or basic parameters, and an action is initiated by the healthcare personnel. In [35], Baccar and Bouallegue have proposed a novel website architecture for an e-Health program based on a wireless sensor network. Designed website offers an ergonomic and multifunctional platform for an intelligent hospital. Features of this website include management of patient's records, real-time monitoring of patient's condition and geo localization for patients as well as professionals involved with the hospital. The system shown in Fig. 7.3, uses remote sensing of biometrics signals for patient's monitoring. The main three functionalities of the proposed website are; (1) *Manage patients records*: Add/Delete and Modify diagnostics for the health file, (2) *Follow the vital signals progress of patients:* Temperature, Blood Pressure, Cardiograph Pulses, etc. and (3) *Localize patients and professionals; mapping service for out-patients.*

In [36], Ahmed and Abdullah have presented an e-Health model from ubiquitous perspective. This model provides data acquisition, archiving, and presentation in the cloud. The proposed model makes use of cloud service architecture (CSA) for

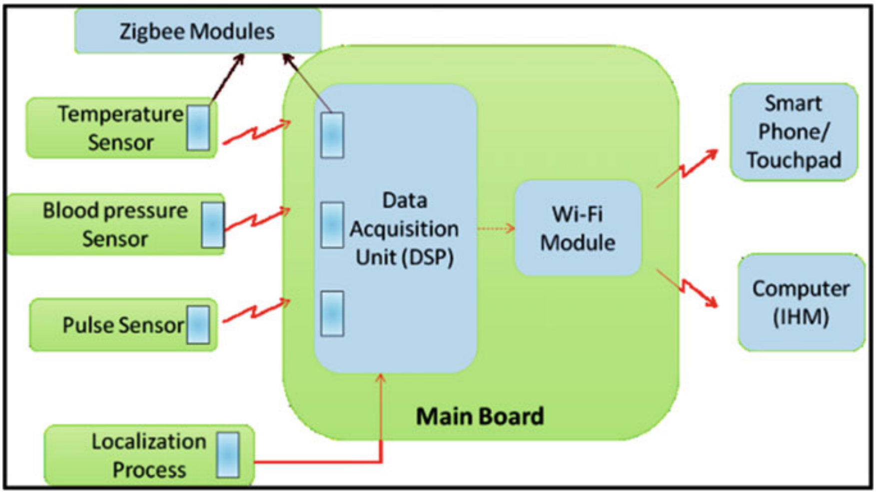

Fig. 7.3 Main board for e-Health platform [35]

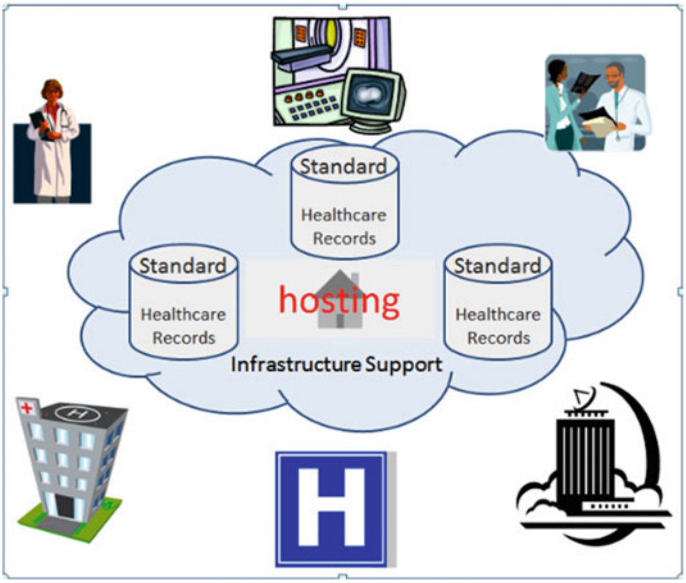

Fig. 7.4 e-Healthcare cloud [37]

processing of medical information of a patient. In another work [37], Liu and Park have focused on the e-Healthcare application cloud-enabling characteristics. The authors of this research work found close proximity of the proposed e-healthcare architecture and the cloud environment. The e-healthcare cloud is shown in Fig. 7.4.

Authors have also discussed the challenges in the adaptation of a pure cloud solution for smart e-healthcare. In [38], Aruna et al. have designed a patient health monitoring system (PHMS) which includes three phases; (1) *collection phase*, (2) *transmission phase* and (3) *utilization phase*. A Body Area Network (BAN) is constructed and used to collect the required data from the patient. PHMS notifies the registered patient with the possible precautionary measures to be carried. It suggests the patient with medical care and further steps to be followed in case of critical conditions. A typical architecture of PHMS is shown in Fig. 7.5.

In [39], Piliouras et al. implemented the Electronic Health Records (EHR) technologies. They have listed various challenges that were experienced while integrating EHR technology within the workflow of an already existing healthcare setting. Authors have also listed the various lessons learned from its implementation: (1) *Identify System Champions*, (2) *Give users a lot of Training*, (3) *Perform Root Cause Analysis* and (4) *Quality Management Principles*. Table 7.2 summarizes various applications designed and implemented for e-Health of user or patient.

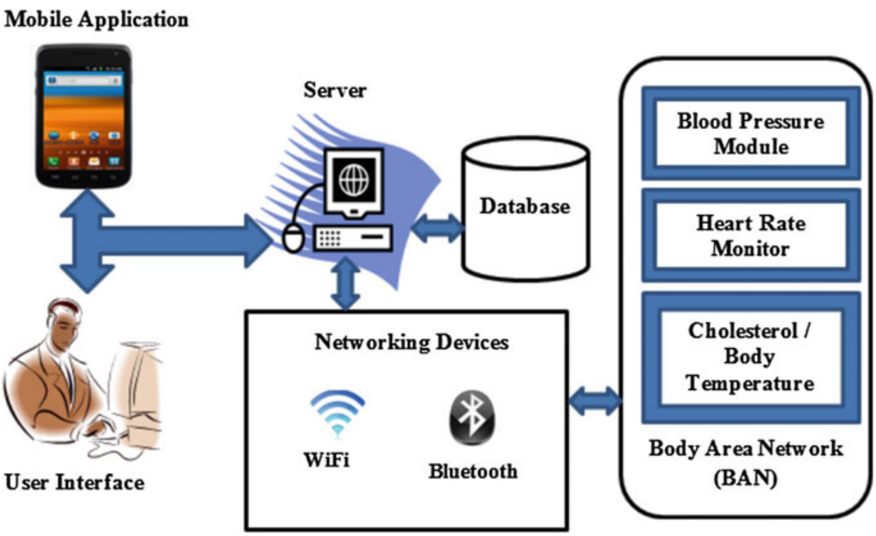

Fig. 7.5 Architecture of PHMS [38]

Table 7.2 Applications for e-Health

S. no.	Application	Purpose
1	IoT-based cloud-centric architecture to perform predictive analysis of user activities in sustainable health centres [34]	A cloud-centric architecture using IoT that uses predictive analysis of the physical activities of the users in maintainable health centres
2	Web-based e-Health platform [35]	A web-based architecture for an e-Health program using a wireless sensor network that offers an ergonomic and multifunctional platform for a smart hospital
3	e-Healthcare management system-based on the cloud-and service-oriented architecture [40]	A smart, and flexible e-Health management system based on cloud computing and SOA and using RIA that overcomes various shortcomings in existing healthcare management systems
4	e-Health monitoring architecture [41]	An intelligent e-Health management system that supports real-time analysis of various parameters of patients using smart devices and wireless sensor networks
5	e-healthcare and data management services in a cloud [36]	An e-Health model that addresses the issues regarding management and security concerns in cloud domain. It includes wireless sensor networks, communication, and storage systems for any hospital using CSA

(continued)

Table 7.2 (continued)

S. no.	Application	Purpose
6	Healthcare cloud computing application solutions [37]	An intelligent cloud-based system that focuses on the cloud-enabling characteristics of e-Healthcare applications
7	Health monitoring and management using internet-of-things (IoT) [42, 43]	An IoT-cloud-based remote patient monitoring system that is used for health monitoring and management
8	Smart real-time healthcare monitoring and tracking System [44]	A smart real-time healthcare monitoring and tracking system that aims to bridge the gap between patients and healthcare professionals
9	IoT-based smart healthcare kit [45]	An intelligent and robust health monitoring system that is capable of monitoring the patient automatically using IoT
10	Remote mobile health monitoring system [46]	A remote mobile health monitoring system that uses mobile and web service capabilities to delivers an end-to-end solution to health-related queries
11	IoT-based remote health monitoring system [47]	An IoT-based health monitoring system that addresses a key challenge to efficiently transmitting healthcare data within the limits of the existing network infrastructure
12	Patient health monitoring system (PHMS) using IoT [38, 48, 49]	An intelligent PHMS that collects patient's sample values and suggests the patient with medical care and further steps to be followed in case of critical conditions
13	Smart cards in healthcare information systems [50–52]	A smart card in healthcare that enables access to a patient's health record stored on network
14	Electronic health record systems [39]	An electronic health record system that uses EHR technologies
15	e-Health tele-media application for patient management [53]	An intelligent e-Health system that provides patients with real-time management of illness, reaction/side effects to prescribed medication, prescription reminders, provides survey data, etc.

7.2.3 e-Logistics

The logistics business has changed dramatically over last few years. Today, the differentiators are more strategic: benchmarking, innovation, network modelling, etc. Employing suitable logistics strategies is a necessity. However, logistic strategy planning is becoming more and more challenging due to dynamically changing scenarios and difficulties in integrating information from different partners. Information from various sources could be combined to generate integrated knowledge that could support the planning process. Integrated knowledge can better describe the potentials of synergy between the available sources of information, and accordingly better exploit logistics strategy planning. In the following proposal, a machine learning-based adaptive framework for logistics planning is proposed. The proposed system will evolve, adapt and improve as its knowledge grows providing a generalized solution to all kinds of logistics activities.

In [54], Khayyat and Awasthi have conducted a study that investigates the problem of collaboration planning in logistics and proposed an agent-based approach for better management of collaborative logistics. Based on the approach, they have designed a support system which utilizes RFID technology for ensuring inventory accuracy. The proposed approach involves three steps: (1) a conceptual agent-based model is designed, (2) the game theory method is utilized to intensively study and analyse suppliers' collaboration and carriers' collaboration that represent major objectives proposed in the preceding model, (3) correctness of the games is verified by formulating them mathematically. Figure 7.6 shows the design of the conceptual multi-agent-based model.

In [55], Wrighton and Reiter have discussed the problem faced in urban cities of Europe, i.e. the transport of goods contributes to the adverse condition of

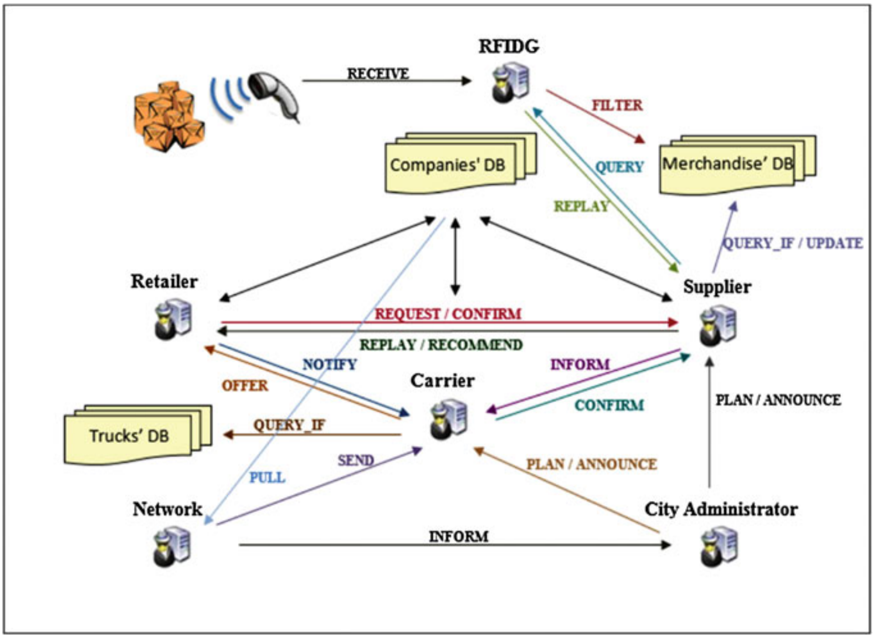

Fig. 7.6 Design of conceptual multi-agent-based model [54]

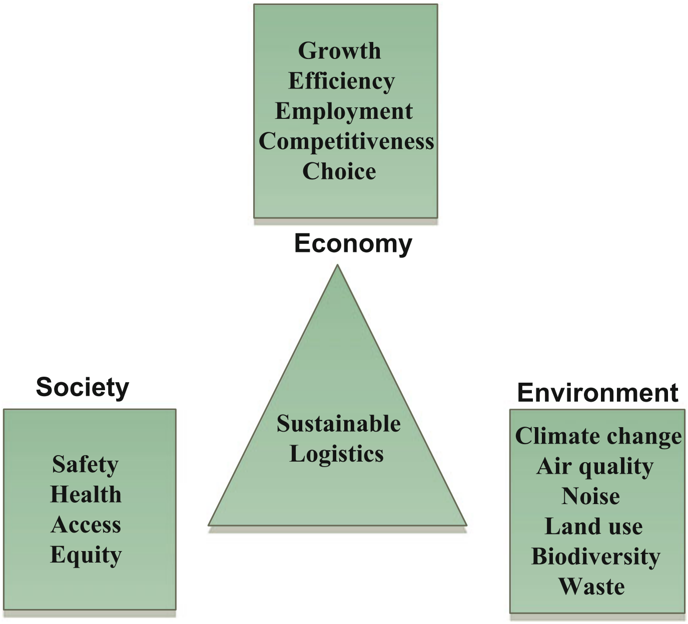

Fig. 7.7 Sustainable logistics dimensions [56]

overcrowding by motorized traffic. City administrators of Europe are aware of the fact that if early measures are not taken to improve this scenario then this will result into a problematic situation. The Cyclelogistics (2011–2014) and Cyclelogistics (2014–2017) projects offer a possible solution to the stated problem. Authors have demonstrated the great potential for the reduction in energy consumption and pollutants caused by urban goods transport by shifting intra-urban final delivery of goods from the car to the bicycle. In [56], the main objective of proposed work is to suggest Smart City logistics on the cloud computing model. Authors have discussed the smart city logistics in terms of sustainable logistics dimensions: Economy, Society and Environment, as shown in Fig. 7.7.

Due to many beneficial characteristics of cloud, the smart logistics has been shifted to cloud computing. Cloud implies a broad range of benefits to the enterprise and other organizations. In [57], the authors have proposed a smart logistics vehicle management system based on Internet of Vehicle (IoV). IoV for smart logistics vehicle management provides various services such as; (1) fleet management, (2) smart driving and (3) transport management. The proposed smart logistics vehicle management consists of following modules based upon the functionality: (1) data collection module, (2) communication module and (3) computational module. In [58], Jianyu and Runtong have represented the model to resolve physical distribution and its effects on E-commerce. Physical distribution is a bottleneck in E-commerce. Authors have constructed the distribution system in

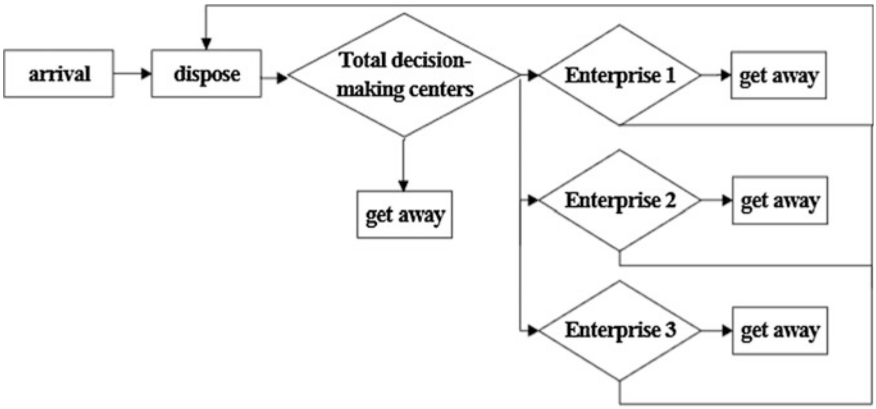

Fig. 7.8 Non-grid simulation logic model diagram about ELS [58]

Table 7.3 Applications for e-Logistics

S. no.	Application	Purpose
1	A comprehensive framework for measuring performance in a third-party logistics provider [59]	A smart framework that provides comprehensive and innovative performance measurement framework for a third-party logistics provider
2	An intelligent multi-agent-based model for collaborative logistics systems [54]	An intelligent multi-agent-based model that has proposed and agent-based approach for better management of collaborative logistics
3	Automobile logistics service supply chain based on reliability [60]	A smart system that deals with building a two-stage automobile LSSC, where the dominant LSI integrates FLSP
4	Cyber-physical logistic systems [61]	An intelligent cyber-physical logistic system that proposes a model for application of innovative techniques for data acquisition and analytics in cyber-physical logistic systems
5	Cyber-physical logistics system-based vehicle routing optimization [62, 63]	A smart routing adjustment model that considers the existing road congestion and minimizes the total distribution in cost. Here, static and dynamic models are proposed for traffic information transmission network
6	Quality of logistics services [64]	A research that deals with the customer satisfaction with services and discusses the importance of relation between the logistic companies and customer satisfaction with logistics services

(continued)

Table 7.3 (continued)

S. no.	Application	Purpose
7	CycleLogistics [55]	A research that demonstrates the great potential for the reduction in energy consumption and pollutants caused by urban goods transport, and discusses how to shift from motorized vehicle to bicycles to change the condition of traffic congestion and over pollution
8	Cyber-physical production systems combined with logistic models [65]	A research that discusses the advantages of cyber-physical systems by considering the production planning, controlling and monitoring
9	Hierarchical integrated intelligent logistics system platform [66]	An intelligent system that proposes HIILS platform for the wide spectrum of the city logistics problems
10	Smart city logistics on cloud computing model [56]	An IoT cloud-based smart city logistics model that deals the smart city logistics in terms of sustainable logistics dimensions
11	Parcel industry in the spatial organization of logistics activities [67]	A research that aims to study the location of parcel industry, and its orientation in the spatial organization of logistics activities in the Paris region
12	Smart logistics [57, 68]	A smart logistics system that proposed a smart logistics vehicle management system based on the IoV
13	e-Commerce logistics in supply chain management [69]	A research that presents the state-of-the-art e-Commerce logistics in supply chain management from practice perspective
14	RFID-based data mining for e-Logistics [70]	An intelligent system that combines RFID for data acquisition, data mining for knowledge discovery and enterprise applications in the field of e-Logistics
15	e-Commerce logistics based on the gridding management [58, 71]	An intelligent e-Commerce logistics-based gridding management system that deals with physical distribution and its effect on e-Commerce

E-commerce logistics based on the gridding management, via the comparison analysis between the grid and non-grid distribution system in E-commerce logistics.

The structure and level of E-commerce logistics system (ELS) consist of (1) function entity, and (2) management level. The proposed framework is shown in Fig. 7.8. Table 7.3 summarizes various applications designed and implemented for e-Logistics.

7.3 Summary

This chapter discusses the applications of predictive computing in real life. It deals with the concept of how and where we can explore predictive computing and deploy the applications. The discussion is concentrated on three case studies where predictive computing can be applied to various applications, namely; smart mobility, e-Health and e-Logistics.

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