Chapter 2
Background and Literature Survey

The study of new maritime wideband communication network commenced to be attracted attention recently. Although the research on video transmission scheduling in maritime wideband communication network is still in the early stage, a large number of counterparts on land-based network have shown up, which could lay down a solid foundation for maritime communication networks. Moreover, little literature with emphasis on video transmission scheduling problem in DTN maritime networks is presented. Many fundamental research issues have not been well studied. We categorize the existing works in the literature related to our works into three research issues.

2.1 Preliminaries: Milestone of Maritime Wideband Network

Emerging maritime wideband network has attracted significant attention in recent years. The line of project investigation began with TRITON [1], in which a wireless mesh network to support multi-hop data delivery in maritime network is investigated. However, this paper does not pay much attention about the scenario that vessels are in low density that DTN-based scheme should be utilized. Resorting cognitive radio technology to maritime scenario, a cognitive maritime mesh/ad hoc network is designed in [2]. While the WiMAX-based mesh technology for ship-to-ship communications with DTN features is explored in [3], and the performance between regular routing protocols and DTN routing protocols is compared. Based on a theoretical model to analyze the ships encounter probability distribution, the data delivery ratio from ships to the BS is derived [4]. In [5], the performance of file delivery in maritime DTN network is investigated. The transmission opportunities are existed only when there is direct link between the two vessels, while in our work, DTN throw-box is employed to transiently store data and raise the transmission opportunity. An approach of utilizing multi-hop WiMAX and mesh network is proposed in [6], to provide Internet access to the Mediterranean Sea without the help of satellite. The MAC and routing schemes that are suitable for such a scenario are investigated, with the network connectivity analyzed. However, it can be considered as a special case because the vessel density is high and Internet access is assumed to be available

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at anytime via the multi-hop mesh network. Besides some classic scheduling algorithms, we compare our work with the existing maritime DTN/none-DTN algorithms based on [1, 5] in Chap. 3.

2.2 Video Transmission Scheduling

Video transmission could provide safety-related monitoring for vessels as above mentioned. Scheduling focuses on decision-making, which plays a particularly important role to ensure that the new telecommunications network effectively meets the needs of the subscriber and operator. As real-time multimedia services have stringent quality-of-service (QoS) requirements to maintain user satisfaction, high quality video streaming over variable bit rate (VBR) channels represents several fundamental challenges in engineering [7]. For video transmission delivery, although there are very few research works in the literature for maritime scenario, a variety of research works on the land communication area appear in the literature. In [8], Fu *et al.* formulated the dynamic scheduling problem as a Markov decision process that explicitly considers the users heterogeneous multimedia data characteristics (e.g. delay deadlines, distortion impacts and dependencies etc.) and time-varying channel conditions. A directed acyclic graph is applied to express the transmission priorities between the different video units. In [9], Pahalawatta *et al.* presented a cross-layer packet scheduling scheme that streams pre-encoded video over wireless downlink packet access networks to multiple users, by designing the user utilities as a function of the distortion of the received video. A fair-scheduling algorithm for the transmission of video frames over wireless links is developed in [10], based on the occupancy of the video decoder buffer. In [11], an energy-efficient algorithm is presented for the video transmission scheduling in wireless P2P live streaming system, to minimize the playback freeze-ups among peers. Muhammad and Zhuang [12] proposed an energy and content-aware video transmission framework that incorporates the energy limitation of mobile terminals and the QoS requirements of video streaming applications. From aforementioned references, video transmission scheduling issues have gained an increasing popularity among various mobile applications.

Generally, video could be regarded as one type of large data, disregarding the unique characteristics. With respect to data transmission delivery, in [13], Yan *et al.* developed a theoretical model to compute the achievable throughput of cooperative mobile content distribution in vehicular ad hoc networks. The IEEE 802.11 p MAC protocol is proposed for video broadcasting in metro passenger communication system, which is specially designed for high-speed trains with a speed up to 360 km/h [14]. In [15], Liang *et al.* proposed a semi-Markov decision process based service model to efficiently manage inter-domain resource allocation in mobile cloud networks. In [16], Cheng *et al.* proposed a vehicle-assisted data delivery method for smart grid applications, based on optimal stopping theory. In [17], three alternatives of vehicular access infrastructure are designed, and the data transmission scheduling based on capacity-cost tradeoffs for different schemes are analyzed. In [18], Liang

and Zhuang investigated on-demand data services for high-speed trains, based on Smith ratio and exponential capacity algorithms. In [19], the two-phase algorithm is leveraged in a joint time slot, power control and rate assignment problem in mobile wireless sensor network. Similar research efforts on transmission and access scheduling in cognitive radio networks can be found in [20, 21]. However, the non-flourish video (or even data) transmission scheduling works of maritime network, contrast sharply with counterpart on land communication network.

In Chap. 3, we utilize the job-machine scheduling method to address Throughput Maximization Problem (TMP) problem. A plenty of TMP algorithms remark machine independent issue. However, duo to limited communication periods, mobile users might contact with APs with machine-dependent time window. Unrelated machines scheduling problem has been studied in [22] firstly, where the time indices in terms of release time, deadline and processing time are all machine dependent. Meanwhile, the scheduling issue relating to machine-dependent time indices is investigated in [23]. However, the scenario is distinct from ours, where the coverage area of APs is consecutive and each user has only one job to transmit. The two-phase algorithm proposed in [19] is utilized to jointly allocate the resources of timeslot, power and rate in mobile WSN. However, it is a parallel machine issue, without considering cooperation transmission.

In this brief, we focus on designing ship-shore video transmission scheduling schemes in DTN maritime communication networks, with the goal of throughput maximization while considering cooperation between different vessels and the heterogeneity of the different videos.

2.3 Energy Modeling Based Video Transmission Scheduling

Driven by environment concerns, the next generation wireless networks are envisioned to make use of renewable energy, which can be harvested from natural and renewable resources, such as solar, wind, tides, etc. Motivated by the relatively high performance-cost ratio, solar and wind power are two of the most common energy sources that have been extensively used by wireless networks, especially by the network infrastructure. For instance, the Green Wifi initiative has developed a low cost, solar-powered, standardized Wifi solution for providing Internet access to developing areas [24]. The wind-powered wireless mesh networks are also applied for emergency network deployment after disasters [25]. However, most existing works concern about research issues under the scenario of traditional energy powered maritime wireless networks. Renewable energy sources are intrinsically dynamic with unstable availability and time varying capacity. As such, when renewable energy is used to power maritime communication networks, its dynamic and unreliable nature will affect the transmission efficiency. Accordingly, these impediments impose significant challenges on the maritime network resource management.

Designing an accurate analytic energy model is an effective method to enhance the energy efficiency. Thus, this energy model should be able to predict the remaining capability of powered devices, with a crucial issue of how to figure out the charging

and discharging models. In [26], a more accurate energy model for wireless sensor node is proposed, and an optimal design method of energy efficient wireless sensor node is described, taking into account of the energy dissipation of circuits in practical physical layer. In [27], a novel energy model for batteries and study the effect of battery behavior on routing in wireless ad hoc networks is introduced, by proposing an online computable discrete-time mathematical model to capture battery discharging behavior. In [28], a detailed analytical model for estimating the total energy consumed to exchange a packet over a wireless link is provided, by considering details such as consumed energy by processing elements of transceivers, packet retransmission, reliability of links, size of data packets and acknowledgments, and also the data rate of wireless links. Similar research efforts on energy modeling can be found in [29, 30].

With respect to energy modeling based video (or data in broader sense) transmission scheduling in green wireless communication, although there are very few works related to maritime communication networks, land-based green wireless communication networks have sprung up around the world recently. Several works address video transmission scheduling over time-varying VBR channels, including the rate-distortion optimized video packet scheduling [31] and routing [32]. However, most of those approaches emphasize the network optimization in terms of throughput, delay and delay jitter, without considering the consequent video quality from the subscriber's perspective, which motivates our work. In [33], a mathematical framework is developed to study the impact of network dynamics on the perceived video quality. The close-form expressions of the video quality are given in terms of start-up delay, playback and packet loss, which provide better clue for our work in Chap. 4. Referring to data transmission scheduling, the authors of [34] identified that green-energy-powered APs provide a cost-effective solution for wireless local area networks (WLANs). In [35], the throw-box is assumed to be able to last for a certain period of time, which can calculate the average power from the capacity of the batteries or harvesting energy from solar panels. In [36], network deployment and resource management issues are investigated in the context of green mesh networks. A placement solution seeking paths with the minimum energy depletion probability is proposed to improve the network sustainability while ensures that the energy and QoS demands of mobile users can be fulfilled. In [37], a network planning problem in green wireless communication network is studied. The relay nodes placement and sub-carrier allocation (RNP-SA) issues are jointly formulated. Authors proposed top-down/bottom-up algorithms to minimize the number of APs powered by renewable energy sources with satisfying the quality of service (QoS) requirement of users.

An accurate analytical model of the power dynamics could effectively adapt to the routing decisions in an energy sustainable wireless network. Most existing works use residual energy of the mean energy charging rate for resource allocation, by either assuming that the energy charging rate is known *a priori* or using an oversimplified model. However, the charging in reality is known to be a complicated and dynamic process due to the restricted energy charging capabilities and diverse charging environments which is usually location dependent [38]. In Chap. 4, scheduling and routing schemes are developed to optimize the video transmission throughput and energy sustainability, based on dynamic $G/G/1$ energy queueing model.

2.4 Summary

This chapter has surveyed the existing literature pertaining to maritime wideband network and video transmission scheduling approaches. It has also presented a comprehensive overview of energy modeling based video transmission scheduling. Extensive comparisons of existing results have been done to reach a better understanding of the importance of our work.

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