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RULEMAP: PROTOCOL-INDEPENDENT PACKET CLASSIFICATION FOR SOFTWARE-DEFINED SATELLITE NETWORK

Abstract

With coverage to inaccessible locations of terrestrial networks, satellite network is an ideal solution for rapidly growing ubiquitous communication requirements in future wireless systems including the emerging sixth-generation (6G) wireless systems. Based on Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) technologies, the seamless integration of satellite networks, terrestrial mobile networks, WiFi and IoT brings new challenges to onboard switching and processing. To realize high-speed switching and fine-gained process for packets with diverse network protocols, an adaptive packet classification method with high performance and low resource utilization is required by satellite switches and other forwarding elements. However, previous algorithmic methods suffer performance degradation as diversity and complexity of protocols and quantity of classification conditions increase. Also, the high-performance ternary content addressable memory (TCAM)-based architectural method is infeasible in satellite due to its high resource utilization, large power consumption and low flexibility.

In this paper, we propose RuleMap as a protocol-independent packet classification method aiming at the demand of software-defined satellite network. RuleMap is based on a specific storage structure which comprises a Packet Classification Unit Array (PCUA) and a Unit Array Map (UAM). PCUA is a group of programmable Packet Classification Standard Units (PCSUs) scattered on the chip and the informations of PCSUs are clustered and recorded in UAM for fast access. Each PCSU can store a certain number of rules on a configurable match field and perform binary search on all rules. Through condition decomposition, sorting, clustering and aggregation, packet classification conditions with diverse protocols can be stored as a set of distributed rules. When a packet arrives, all PCSUs are traversed in order according to UAM and the match results are collected after traverse. Then, through a series of matrix transformations on the collected match results, the final matched condition is returned.

Theoretical analysis and simulation experiments show that RuleMap can achieve stable packet classification speed as TCAM-based method. Also, RuleMap outperforms TCAM-based method in four aspects: I) reduce logic resources utilization by 90% and reduce memory resources utilization by 50% to 90% in FPGA implementation; II) higher scalability since new PCSUs can be added into PCUA without causing performance degradation. III) higher adaptivity for future protocol evolution due to the programmability on storage structure; IV) higher reliability since failure or error in one PCSU dose not affect the functionality of other PCSUs.