# Chapter 5 – Internet and Higher Layer Protocols

* Two approaches to structure a network in a Control Plane
  + Per-router control (Traditional Approach) –   
    In this every router, every router communicates with each other in control plane and then develop the forwarding tables.
  + Logically centralized Control (S/W Approach) –   
    There is a remote controller, that interacts with the local control agents in the router to compute the forwarding tables.
* Routing Protocols
* Path is a sequence of routers that a packet will traverse in going from an initial Source host to Final Source host.
* All global routing algorithms have info about link cost in the whole topology. Hence, they are “link state” algorithms
* The routers which have link cost info of about the physically connected neighbors, which use an iterative approach for computation and exchange of information are called as “Distance Vector” algorithms.
* Link State Routing Algorithms
  + Dijkstra’s Algorithm:
* Distance Vector Algorithms

Bellman-Ford Equation -

* Intra-Autonomous Systems Routing – Interior Gateway Protocol (IGP)  
  The routing amongst the same host/routers in an AS. All routers need to have same intra-domain protocol in a single AS. There is a gateway-router, which links one AS to another
  + RIP – Routing Information Protocol
  + OSPF – Open Shortest Path First
    - It uses Link State Packet Dissemination. Hence, it has a topology map at each node.
    - It computes routes using Dijkstra’s Algorithm.
    - It allows multiple paths bearing **same-cost**
    - **The router floods the OSPF link-state advertisements to all the routers in the entire AS. It carries all the packets/ messages over IP Address.**
  + Hierarchical OSPF
    - Two-level Hierarchy
      * Each node has a detailed area topology, only knows directions to the nets of the other areas
    - Area Border Routers (ABR)
      * Summarize distance to nets in its own area, adv in other ABR
    - Backbone Routers
      * It limits OSPF routing to backbone
    - Boundary Routers
  + IGRP – Interior Gateway Routing Protocol
* Inter-Autonomous Systems Routing

It is a method of routing between different AS. Gateways are used to perform Inter-AS Routing

* + Border Gateway Protocol (BGP) –
    - eBGP – To obtain subnet reachability information from neighboring AS.
    - iBGP – To propagate reachability information to all internal-AS routers.
    - It also allows every subnet to advertise its location
    - Advertised Prefix includes BGP attributes. There are 2 important attributes.
      * AS-PATH – list of AS’s through which prefix adv. has passed.
      * NEXT\_HOP – indicates specific internal-AS router to next-hop AS.
    - Policy-based Routing – Gateways uses import policy to accept/ decline all the incoming advertisements. It also determines whether to advertise path to the neighboring AS’s
    - BGP Messages – Open; Update; KeepAlive; Notification.
  + Hot Potato Routing –

Irrespective of the increased number of hops between inter-AS routers, this routing protocol selects the router which has the least intra-domain link weight.

* SDN – Software Defined Networking
  + It has SDN Controller (network OS) –
    - It maintains network state information
    - Interacts with network-control application via northbound API. Viz routing, access control, load balance.
    - Interact with network switches below via southbound API.
* OpenFlow Protocol
  + It operates between controller and switches. It uses TCP to exchange messages
  + There are 3 classes
    - Controller- to -switch-
      * It queries the switch features, configuration parameters and replies to switches.
      * It performs CRUD on flow entries and can also send this packet out, from any particular port.
    - Asynchronous (Switch to Controller) –
      * It transfers packets to controller, receives packet-out messages
      * Maintains the flow table entries. It adds the flow table entries to switch from where it is been deleted.
      * It informs controller about the change of the port
    - Symmetric (misc)
* Internet Control Message Protocol (ICMP) –
  + It is used for error reporting. It can communicate network level information from one host/router to another. It mentions about an unreachable host, network, port, or protocol
  + ICMP messages are carried in IP datagrams. The IP datagram consist of “Type”, “Code”, and then 8 error bits of IP datagram causing error.
* Network Management – The deployment, integration and coordination of the H/W, S/W and human elements to monitor test, configure, analyze, evaluate and
* Managed devices contains managed objects whose data is gathered into a Management Information Base (MIB).