

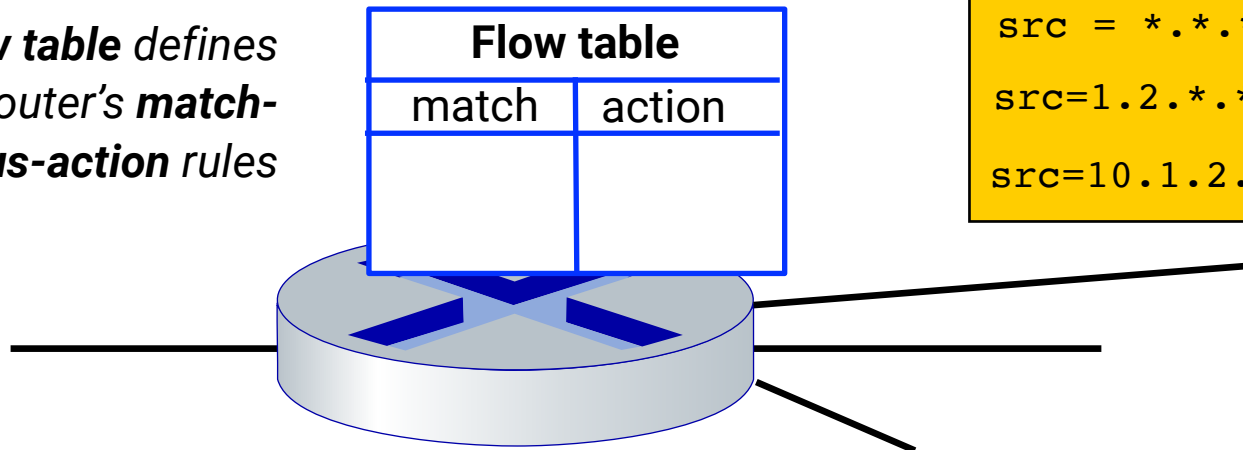
New Abstraction: match-plus-action

Flow: defined by header field values (in link-, network-, transport-layer fields)

Generalized Forwarding: simple packet-handling rules

- *match*: pattern values in packet header fields
- *actions*: drop, forward, modify or send to controller
- *priority*: disambiguate overlapping patterns

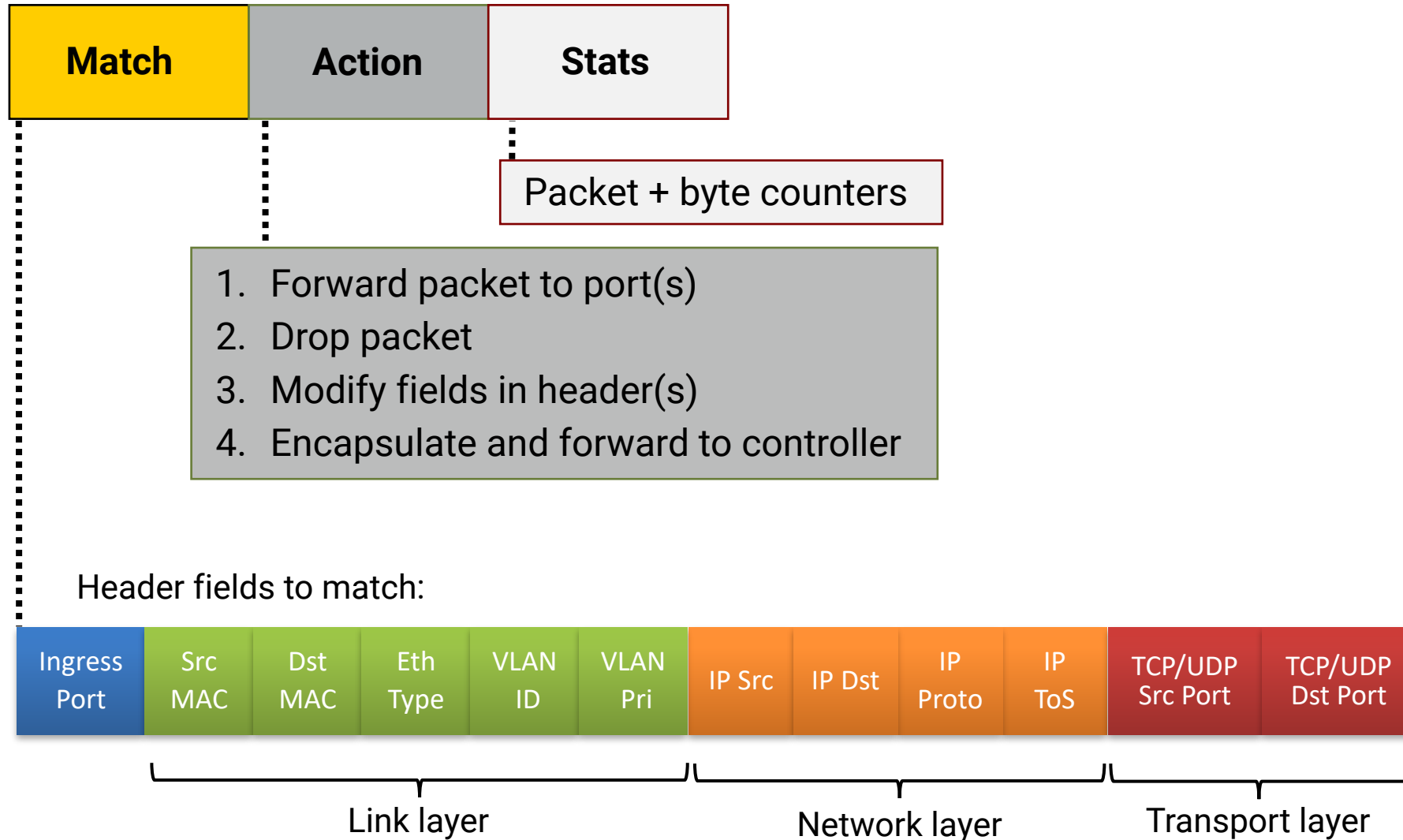
Flow table defines
the router's **match-
plus-action** rules



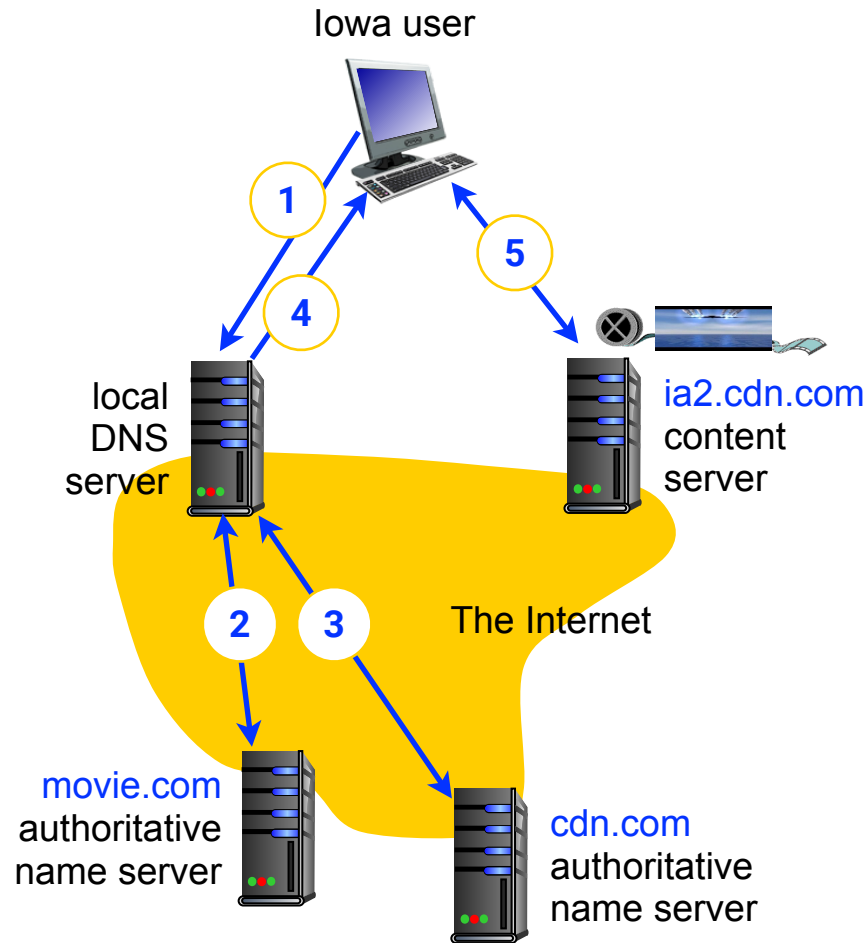
an example flow table

<code>src = *.*.*.*, dest=3.4.*.*</code>	<code>forward(2)</code>
<code>src=1.2.*.*, dest=*.*.*.*</code>	<code>drop</code>
<code>src=10.1.2.3, dest=*.*.*.*</code>	<code>send to controller</code>

OpenFlow: flow table entries



CDN operation



1. **DNS lookup:** User visits *movie.com*, and user's host sends a DNS query to the local DNS server
2. **CDN handover:** local DNS server relays the query to an authoritative name server for *movie.com*. Instead of an IP address, it returns the name of its CDN operator
3. **Content server selection:** local DNS server sends another query to *cdn.com*, to which the CDN responds with the IP address of the chosen/nearby content delivery server
4. **DNS response:** local DNS forwards the IP address of the content serving CDN node, *ia2.cdn.com*
5. **Content flow:** client establishes a *TCP* connection with the local content server, and sends *HTTP GET* request for the video

Real-world CDNs

NETFLIX

You Tube

Operator	2007 - 2012: Akamai, Limelight, Level 3 2012 onwards: Self owned and operated	Google CDN (since 2006)
Architecture	Hybrid: ~200 IXP locations, ~100 ISPs. Offered free of cost to any ISP/IXP	Hybrid: several hundred IXP and ISP locations. Offered free of cost to any ISP/IXP
CDN content	Preprocessing on Amazon cloud; Netflix refreshes CDN content daily (i.e push caching)	Preprocessing on Google data centers; Employs DNS redirect and pull caching (lecture-7)
Streaming	DASH w/ manifest file	HTTP Streaming, choice of bit rate left to users

Ponder about: network **neutrality** | network **economics** | network **principles**