

L45 - Internet Routing Overview

Internet Routing Overview

AS, IGP, EGP, BGP

Agenda

- **Routing at Large**
- **Types of Autonomous Systems**
- **EGP-2**
- **Introduction BGP**

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Routing in Small Networks

- **in small networks**
 - distance vector or link state protocols like RIP or OSPF can be used for dynamic routing
 - it is possible that every router of the network knows about all destinations
 - all destination networks will appear in the routing tables
 - routing decisions are based on technical parameters
 - e.g. hop count, link bandwidth, link delay, interface costs
 - it is sufficient that routing relies only on technical parameters
 - small networks will be administered by a single authority
 - non-technical parameter like traffic contracts have no importance

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Routing in Large Networks

- **with increasing network size limitations of these protocols can be recognized**
 - some limitations for example
 - maximum hop count (RIP)
 - time to transmit routing tables (RIP) on low speed links
 - CPU time for SPF calculation (OSPF)
 - memory used for storing routing table (RIP, OSPF)
 - memory used for storing topology database (OSPF)
 - two level hierarchy centered around a core network (OSPF)
 - route fluctuation caused by link instabilities (OSPF)
 - routing based on non-technical criteria like financial contracts or legal rules is not possible

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Routing in the Internet

- **limitations prevent using routing protocols like RIP or OSPF for routing in the Internet**
 - note: routing tables of Internet-core routers have about 65.000 net-ID entries
- **routing in the Internet**
 - is based on non-technical criteria like financial contracts or legal rules
 - policy routing
 - e.g. Acceptable Use Policy (AUP) in parts of the Internet
 - e.g. contracts between Internet Service Providers (ISP)
 - we need means to support these issues

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Routing Hierarchy, Autonomous Systems

- **routing hierarchy is necessary for large networks**
 - to control expansion of routing tables
 - to provide a more structured view of the Internet
- **routing hierarchy used in the Internet**
 - based on concept of autonomous system (AS)
- **AS concept allows**
 - segregation of routing domains into separate administration domains
 - note:
 - routing domain is a set of networks and routers having a single routing policy running under a single administration

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IGP, EGP

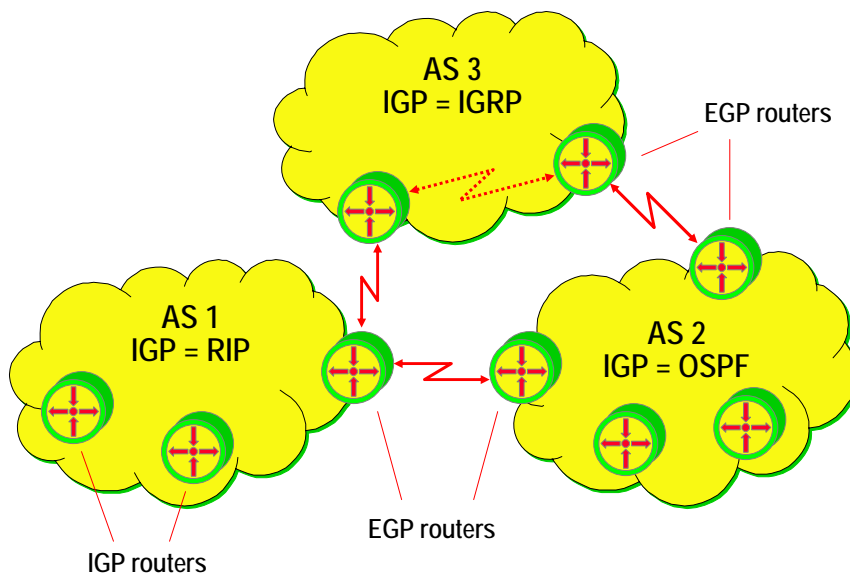
- **within an AS one or more IGP protocols provide interior routing**
 - IGP - Interior Gateway Protocol
 - IGP examples
 - RIP, RIPv2, OSPF, IGRP, eIGRP, Integrated IS-IS
 - IGP router responsible for routing to internal destinations
- **routing information between ASs is exchanged via EGP protocols**
 - EGP - Exterior Gateway Protocols)
 - EGP examples
 - EGP-2, BGP-3, BGP-4
 - EGP router knows how to reach destination networks of other ASs

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AS, IGP, EGP



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AS Numbers

- **hierarchy based on ASs allows forming of a large internetwork**
 - by dividing it into smaller and more manageable units
 - every unit may have its own set of rules and policies
- **AS are identified by a unique number**
 - can be obtained like IP address from an Internet Registry
 - e.g. RIPE NCC (reséaux IP Européens Network Coordination Center)

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Types of AS

- **single homed (stub) AS**
 - networks outside its domain can be reached via single exit point
- **multi-homed non-transit AS**
 - has more than one exit point to the outside world but cannot be used for transit traffic by other ASs
 - multi-homed to one provider
 - multi-homed to different providers
- **multi-homed transit AS**
 - has more than one exit point to the outside world and can be used for transit traffic by other ASs

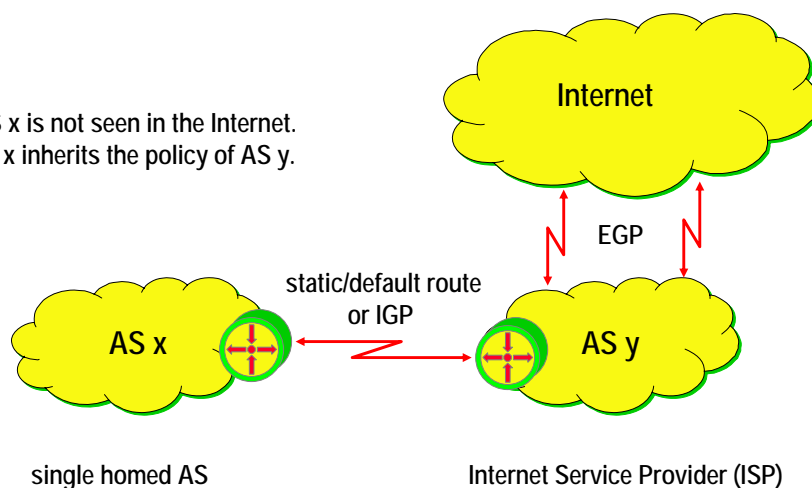
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Single-homed AS

AS x is not seen in the Internet.
AS x inherits the policy of AS y.

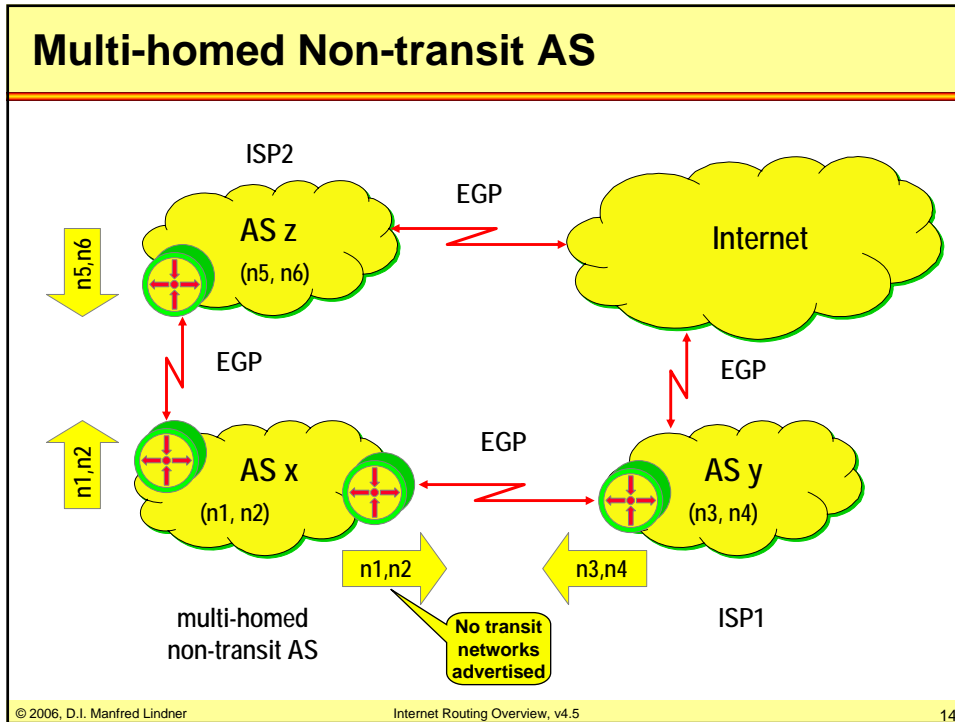
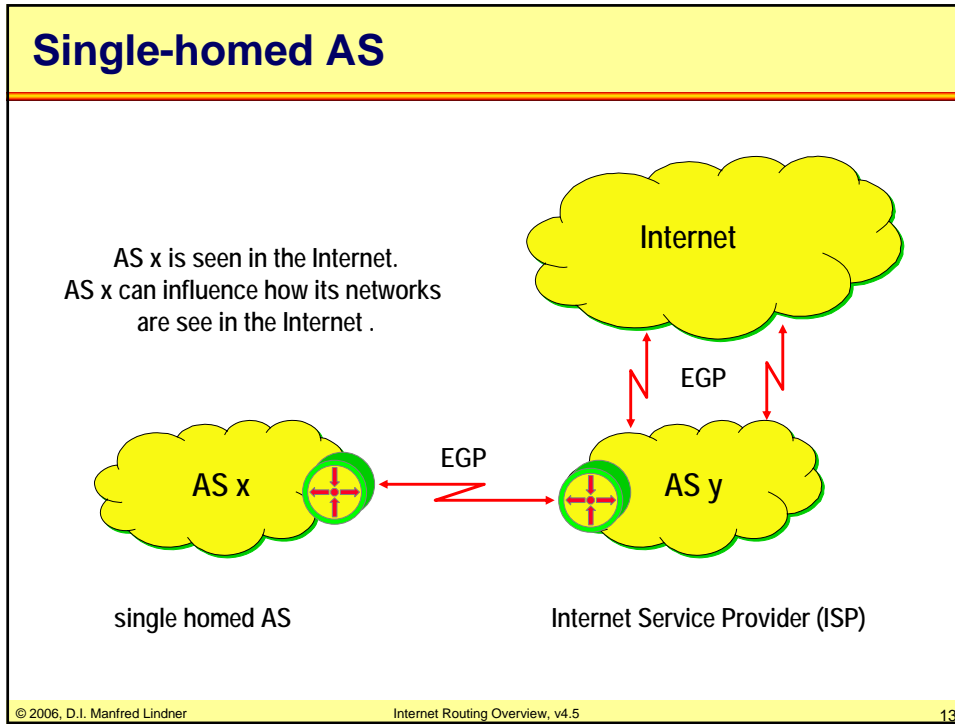


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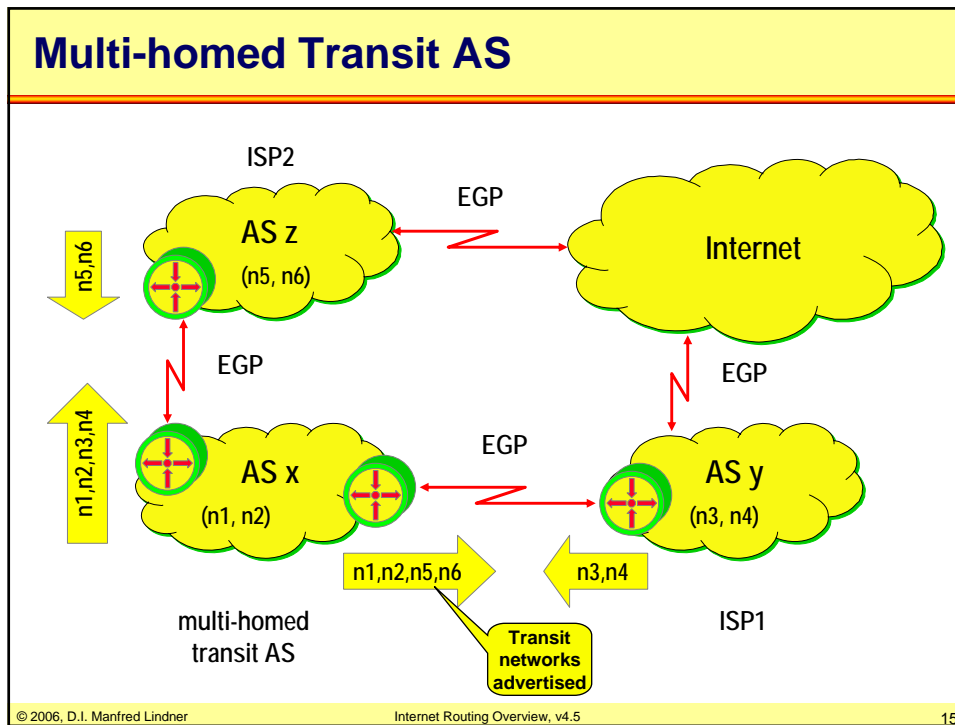
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EGP-2 Basics

- **EGP defined in RFC 827 and 904**
 - Internet standard 18, now historic
- **be careful**
 - EGP ... family of exterior gateway protocol
 - RFC 827/904 ... one implementation of an EGP
 - now we talk about RFC 827 / 904 (EGP-2)
- **EGP-2 session**
 - relationship between two EGP routers connected to the same physical network exchanging network reachability information between two ASs
 - composed of three separate procedures

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EGP-2 Procedures

- **neighbor acquisition procedure**
 - EGP messages: request, confirm, refusal (session setup)
 - EGP messages: cease, cease acknowledgement (session clear)
 - parameter exchange
 - AS number
 - hello interval (typical value 30 seconds)
 - poll interval (typical value 2 minutes)
- **neighbor reachability procedure**
 - EGP messages: hello, I-H-Y (I Hear You)
 - periodical keepalive

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EGP-2 Procedures

- **network reachability procedure**

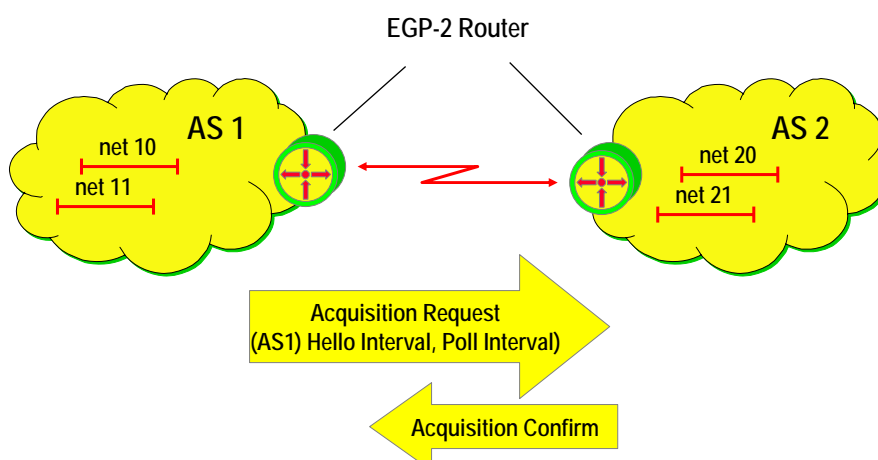
- EGP messages: poll, update
- periodical exchange of complete EGP routing information
- concept of IP Source Network and redirection
 - AS interior routers can share the same physical network, which is used by EGP routers for their EGP session
- EGP metric
 - distance from IP Source Network
 - used as indication of reachability
 - 255 means that network is not reachable
 - may be used for indication of preferred route in case of redundancy between two AS's
 - primary link
 - backup link

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EGP-2 Neighbor Acquisition

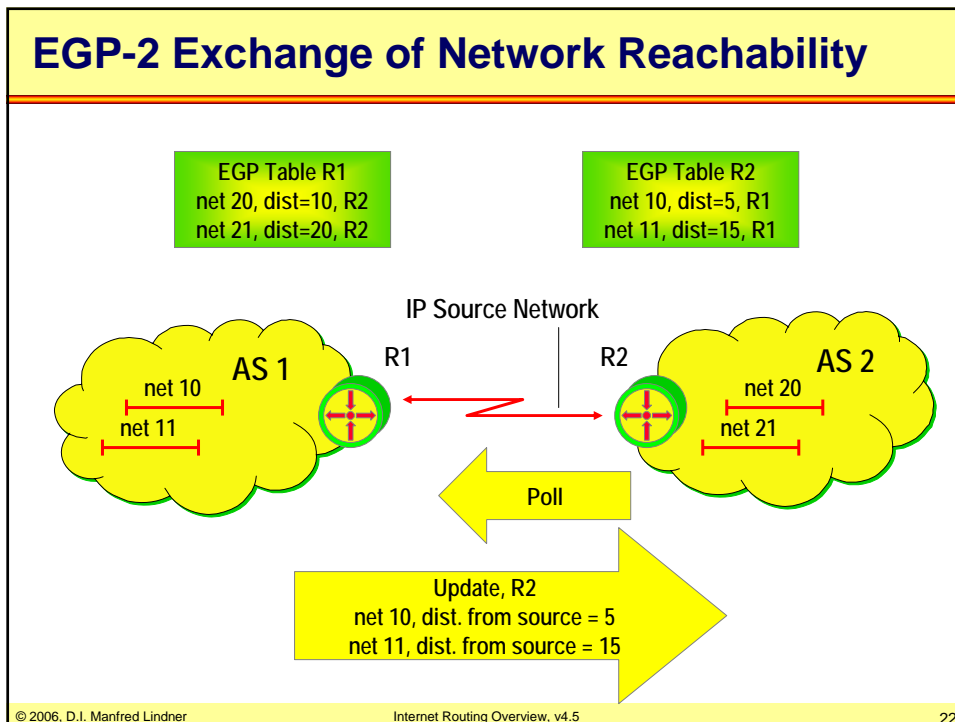
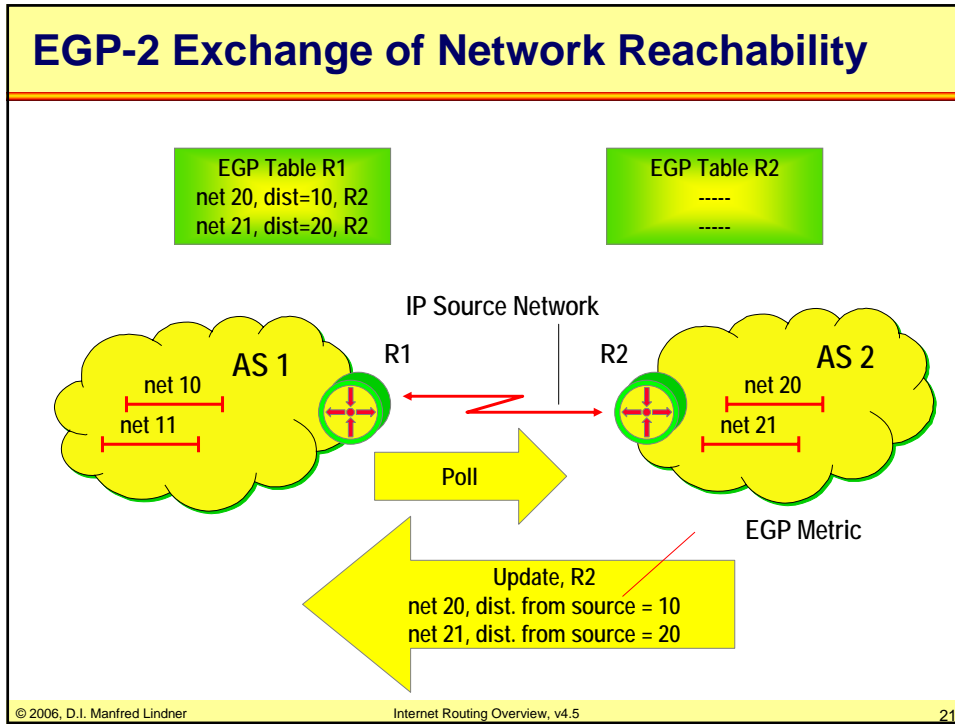


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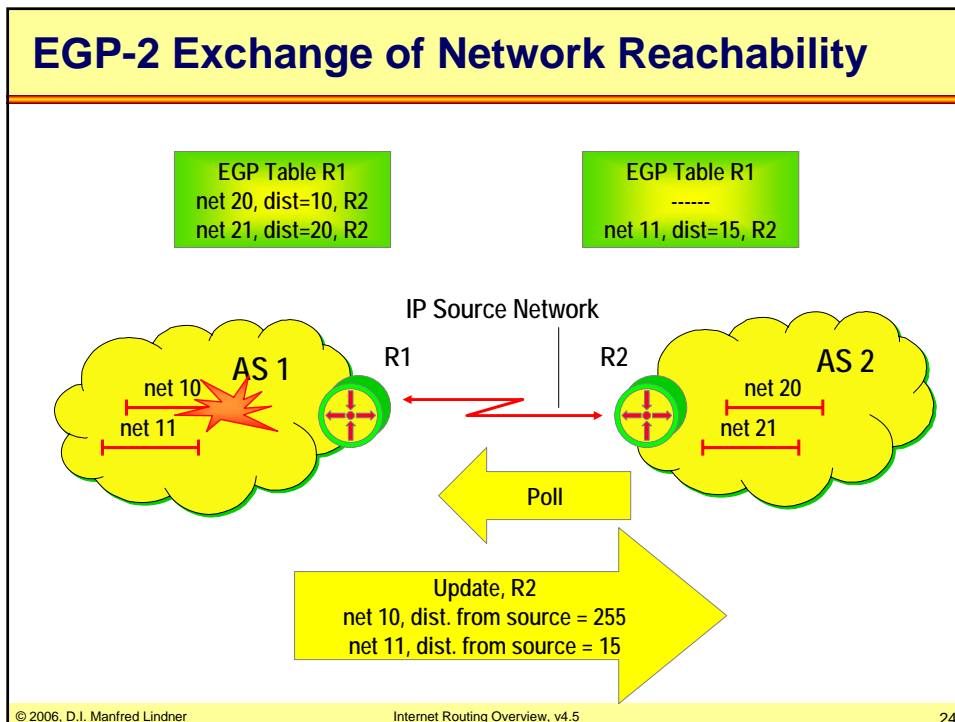
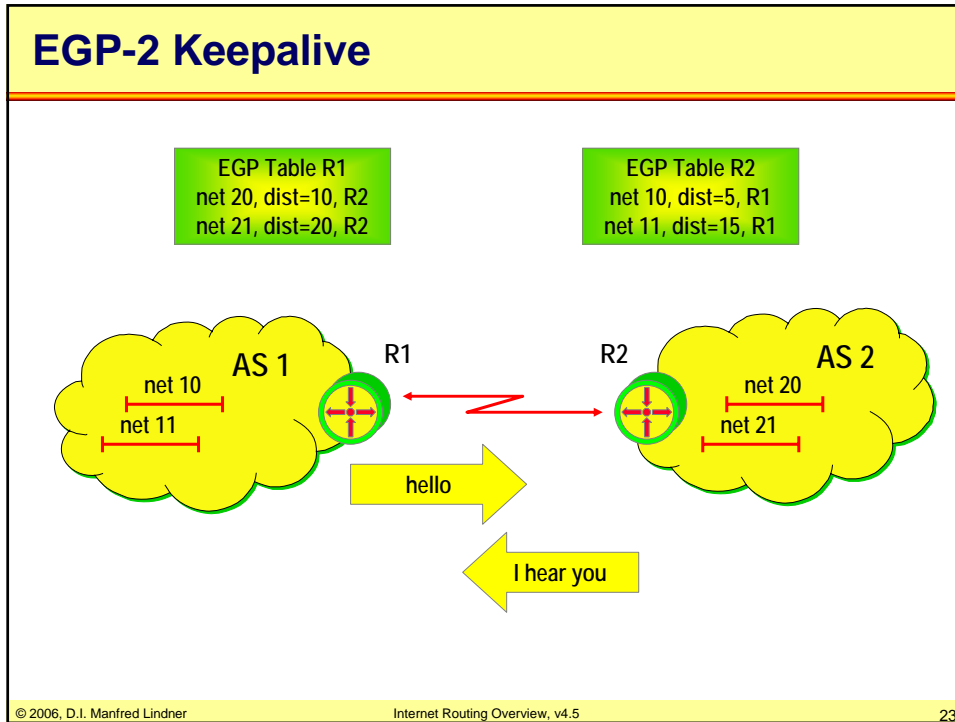
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EGP-2 Limitations

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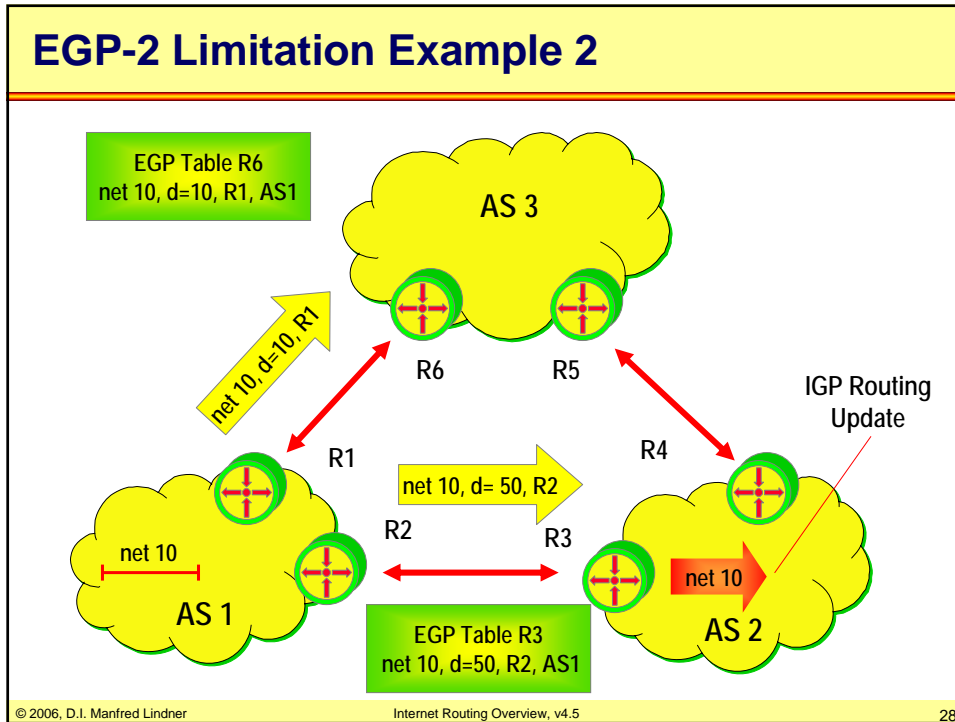
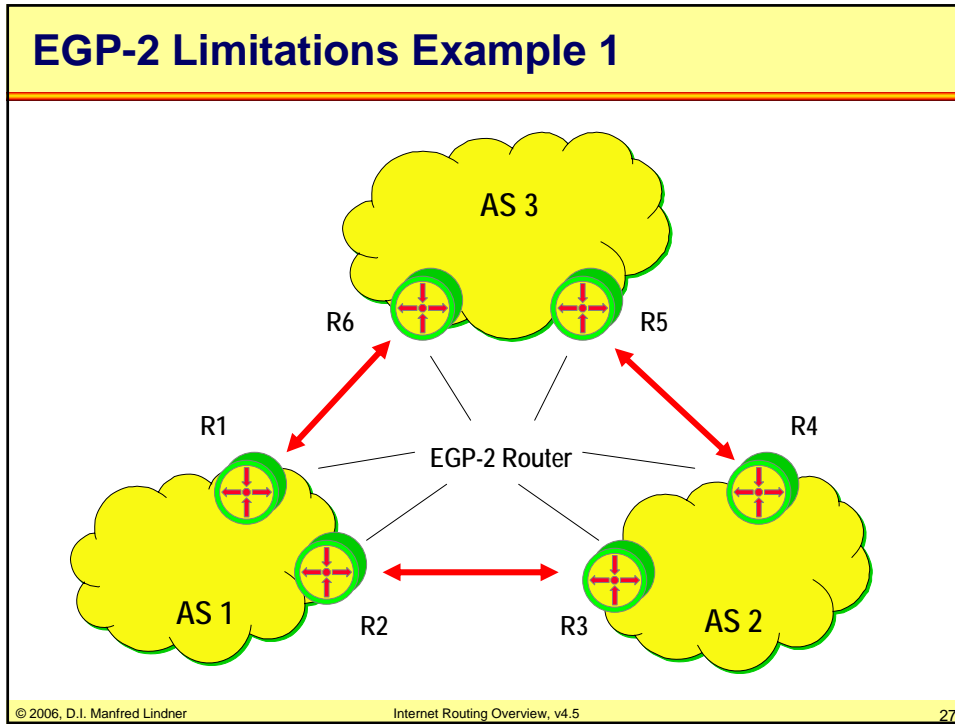
- **EGP was designed for simple hierarchical topology**
 - stub AS connected to a backbone
 - note: early Internet was organized around a core
 - EGP does not specify how to map an EGP distance to the metric of an interior protocol
 - therefore third party rule
 - only internal networks of an AS should be announced by EGP
 - that is problem if a routing policy should be installed

EGP-2 Limitations

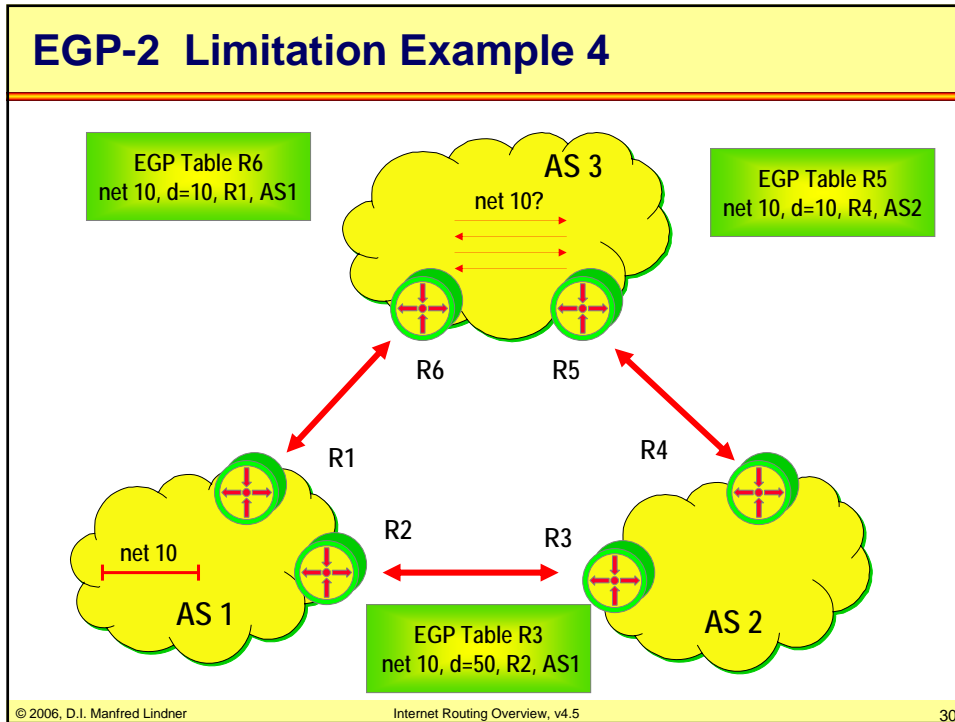
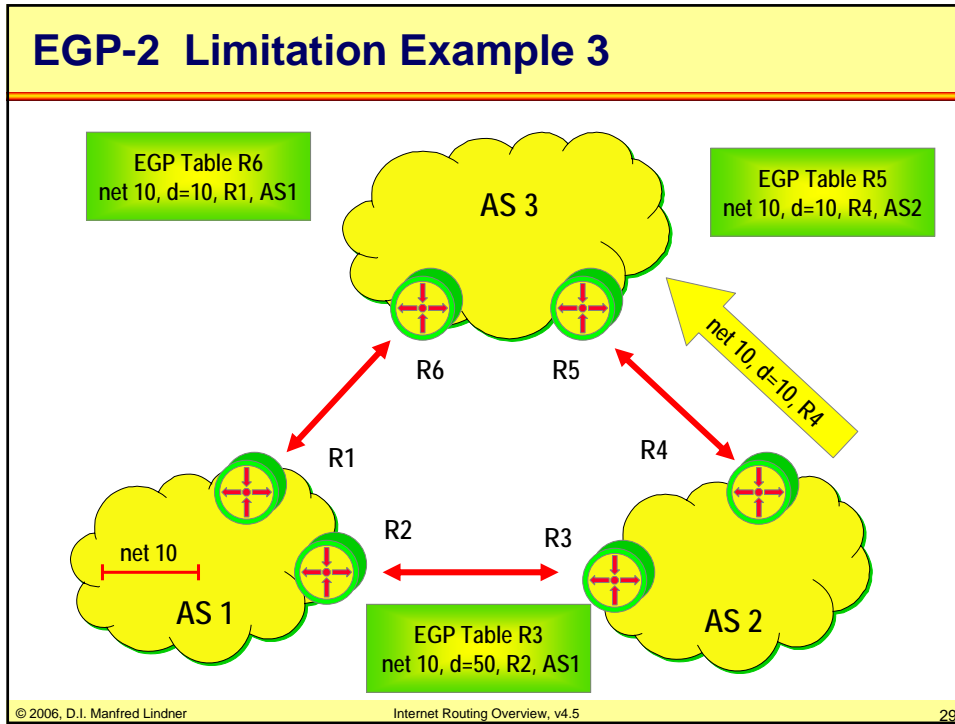
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- **(Cont.)**
 - EGP is more a reachability protocol than a general routing protocol
 - in principle EGP can be used in a more general tree-structured topology (loop-less graph) but routing policy based on distances must be carefully engineered
 - EGP definitely not designed for meshed topology

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EGP-2 Facts

- **EGP-2 is a historical protocol**
 - should be avoided
 - basis for understanding BGP features
- **Implemented by most vendors, even for NOS**
 - e.g. Novell MPR built-in into NetWare 4.x and 5.x
- **Not designed for meshed networks**
 - no built-in mechanism to avoid routing loops
 - might be handled by careful filtering, but this is clearly not scalable

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BGP-4

- **Border Gateway Protocol (BGP)**
 - is the Exterior Gateway Protocol used in the Internet nowadays
 - was developed to overcome limitations of EGP-2
 - RFC 1267 (BGP-3) older version
 - classful routing only
 - RFC 1771 (BGP-4) current version, DS
 - classless routing
 - is based on relationship between neighboring BGP-routers
 - peer to peer
 - called BGP session or BGP connection

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BGP-4 Concepts 1

- **Border Gateway Protocol (cont.)**
 - primary function
 - exchange of network reachability information with other autonomous systems via external BGP sessions
 - but also within an autonomous system between BGP border routers via internal BGP sessions
 - BGP session runs on top of TCP
 - reliable transport connection
 - well known port 179
 - TCP takes care of fragmentation, sequencing, acknowledgement and retransmission
 - hence these procedures need not be done by the BGP protocol itself

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BGP-4 Concepts 2

- **basic ideas**

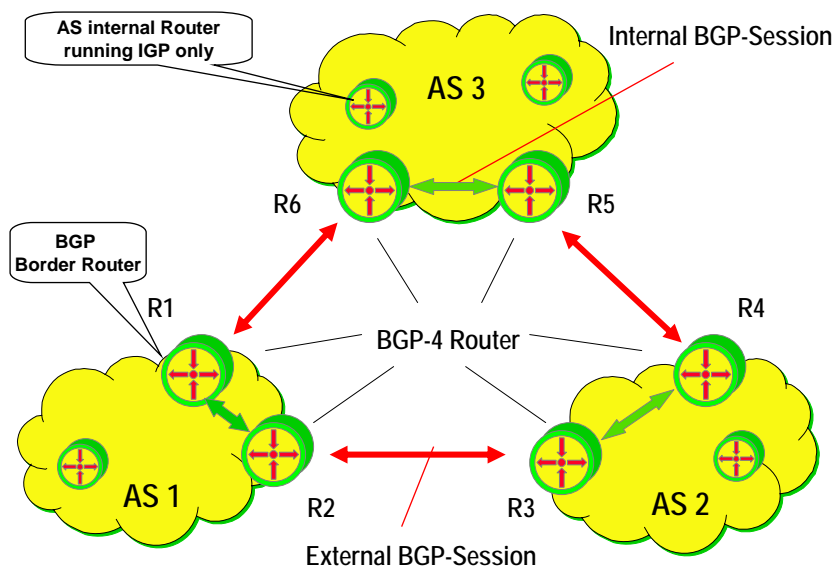
- reachability information exchanged between BGP routers carries a sequence of AS numbers
 - indicates the path of ASs a route has traversed
- path vector protocol
- this allows BGP to construct a graph of autonomous systems
 - loop prevention
 - no restriction on the underlying topology
- the best path
 - minimum number of AS hops
- incremental update
 - after first full exchange of reachability information between BGP routers only changes are reported

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BGP-4 Basic Example (1)

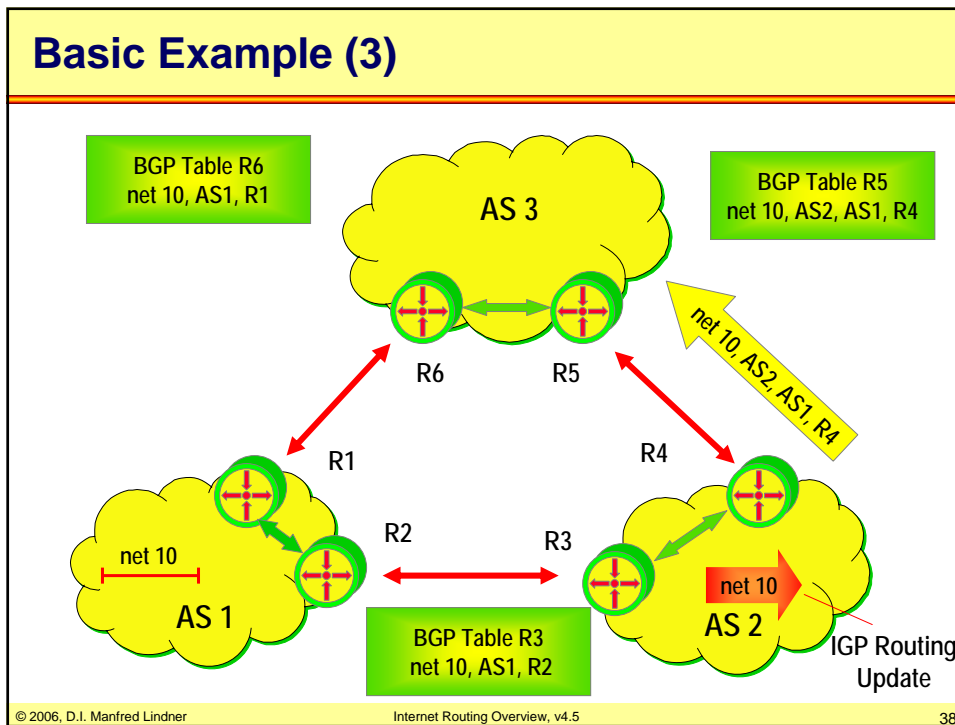
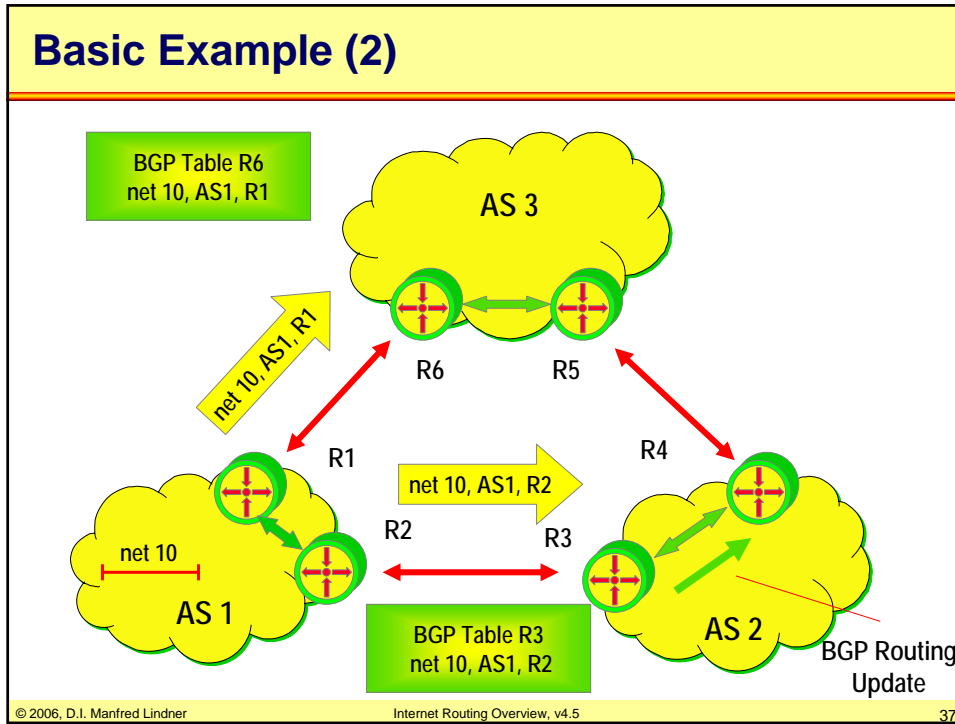


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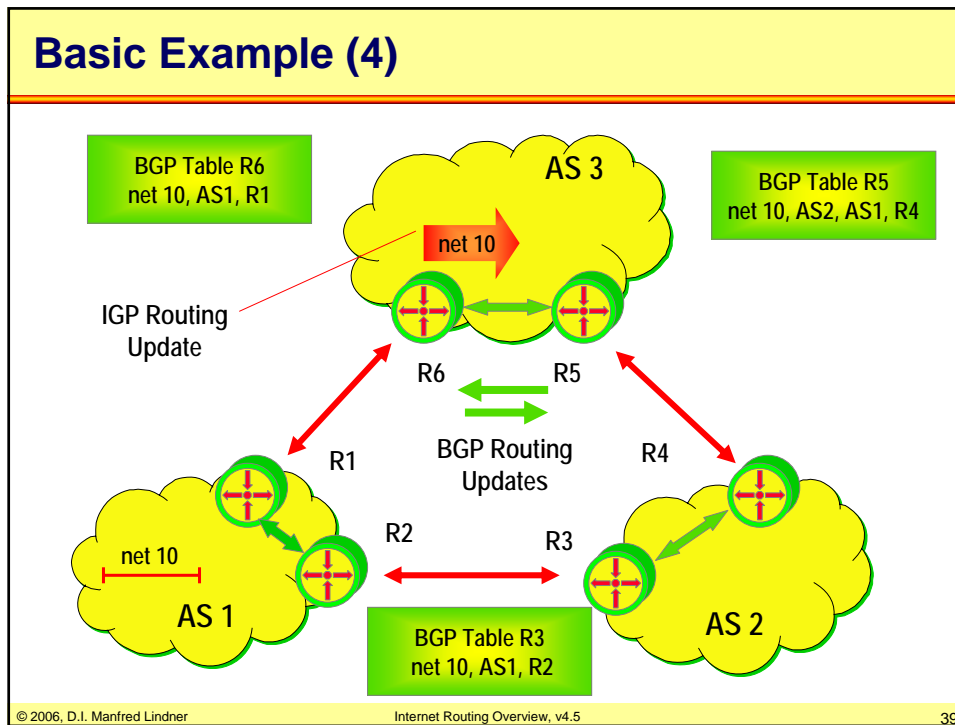
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BGP-4 Concepts 3

- **basic ideas (cont.)**
 - description of reachability information by attributes
 - for BGP routing
 - for establishing of routing policy between AS's
 - BGP-4 advertises so called BGP routes
 - a BGP route is unit of information that pairs a destination with the path attributes to that destination
 - IP prefix and mask notation
 - supports VLSM
 - supports aggregation (CIDR) and supernetting
 - routes can be filtered using attributes, attributes can be manipulated
 - > routing policy can be established

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