Advanced Research Issues In Security: Securing Key Internet Technologies

CS 236

On-Line MS Program

Networks and Systems Security

Peter Reiher

Outline

- Routing security
- DNS security

Routing Security

- Routing protocols control how packets flow through the Internet
- If they aren't protected, attackers can alter packet flows at their whim
- Most routing protocols were not built with security in mind

Routing Protocol Security Threats

- Threats to routing data secrecy
  - Usually not critical
- Threats to routing protocol integrity
  - Very important, since tampering with routing integrity can be bad
- Threats to routing protocol availability
  - Potential to disrupt Internet service

What Could Really Go Wrong?

- Packets could be routed through an attacker
- Packets could be dropped
  - Routing loops, blackhole routing, etc.
- Some users' service could be degraded
- The Internet's overall effectiveness could be degraded
  - Slow response to failures
  - Total overload of some links
- Many types of defenses against other attacks presume correct routing

Where Does the Threat Occur?

- At routers, mostly
- Most routers are well-protected
  - But . . .
  - Several vulnerabilities have been found in routers
- Also, should we always trust those running routers?

Different Types of Routing Protocols

- Link state
  - Tell everyone the state of your links
- Distance vector
  - Tell nodes how far away things are
- Path vector
  - Tell nodes the complete path between various points
- On demand protocols
  - Figure out routing once you know you two nodes need to communicate

Popular Routing Protocols

- BGP
  - Path vector protocol used in core Internet routing
  - Arguably most important protocol to secure
- RIP
  - Distance vector protocol for small networks
- OSPF
- ISIS
- Ad hoc routing protocols

Fundamental Operations To Be Protected

- One router tells another router something about routing
  - A path, a distance, contents of local routing table, etc.
- A router updates its routing information
- A router gathers information to decide on routing

Protecting BGP

- BGP is probably the most important protocol to protect
- Handles basic Internet routing
- Works at autonomous system (AS) level
  - Rather than router level

BGP Issues

- BGP is spoken (mostly) between routers in autonomous systems
- On direct network links to their partner
- Over TCP sessions that are established with known partners
  - Easily encrypted, if desired
- Isn't that enough to give reasonable security?

A Counterexample

- Pakistan became upset with YouTube over posting of "blasphemous" video (2008)
- Responded by injecting a BGP update that sent all traffic to YouTube to a site in Pakistan
  - Which probably dropped it all
- Rendered YouTube unavailable worldwide (well, 2/3s of world)
  - Probably due to error, not malice

How Did This Happen?

- Pakistan injected a BGP update advertising a path to YouTube
  - Which they had no right to do
- It got automatically propagated by BGP
- Everyone knows YouTube isn't in Pakistan
- But the routing protocol didn't
- Security required to prevent other future incidents

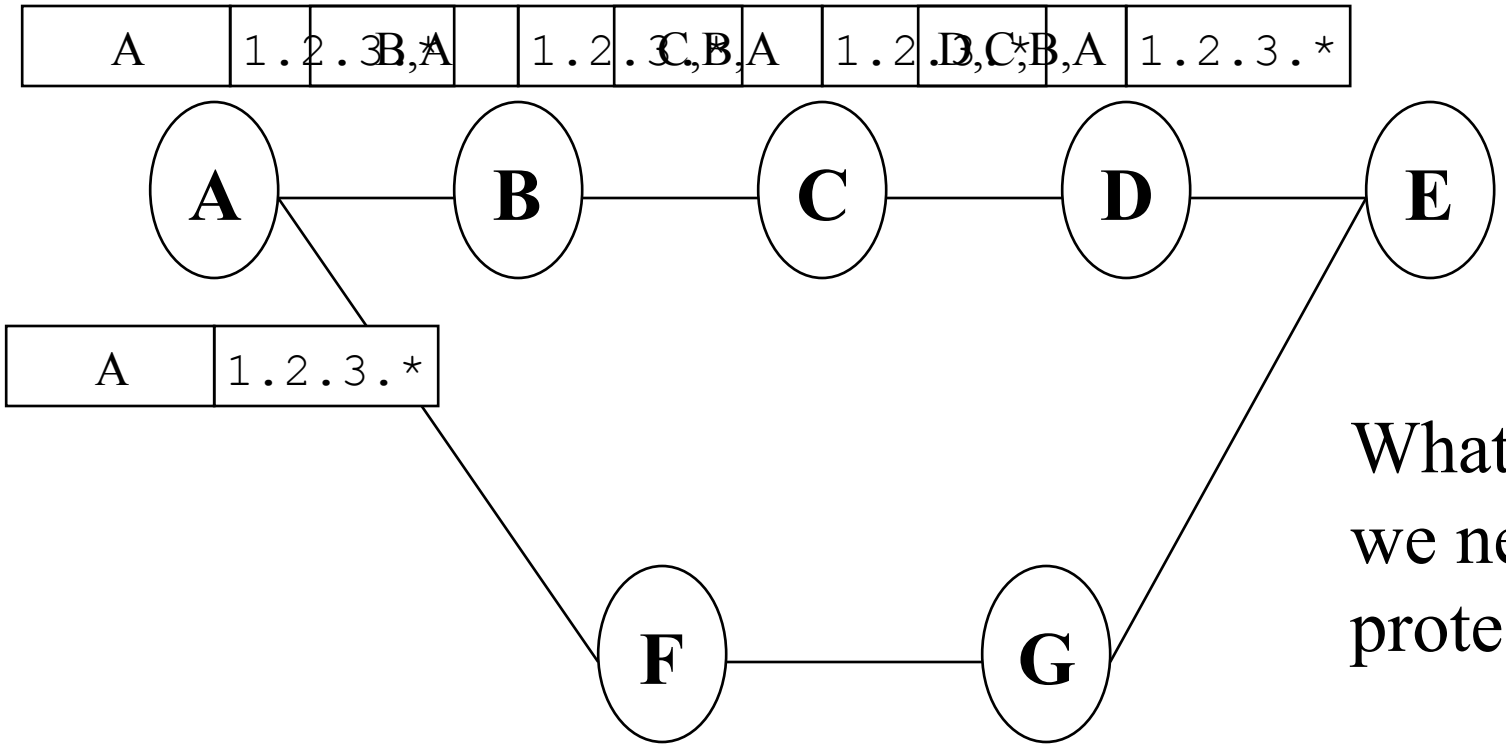
Another Example

- In 2010, China rerouted a lot of US traffic through its servers
  - Traffic purely internal to the US
  - Lots of military, government, commercial traffic
- Based on bogus BGP route advertisements
- Possibly errors, not attacks, but . . .

A Side Issues on This Story

- Much Internet design assumes major parties play by the rules
- Pakistan didn't
- Not desirable to base Internet's security on this assumption
- Though sometimes not many other choices

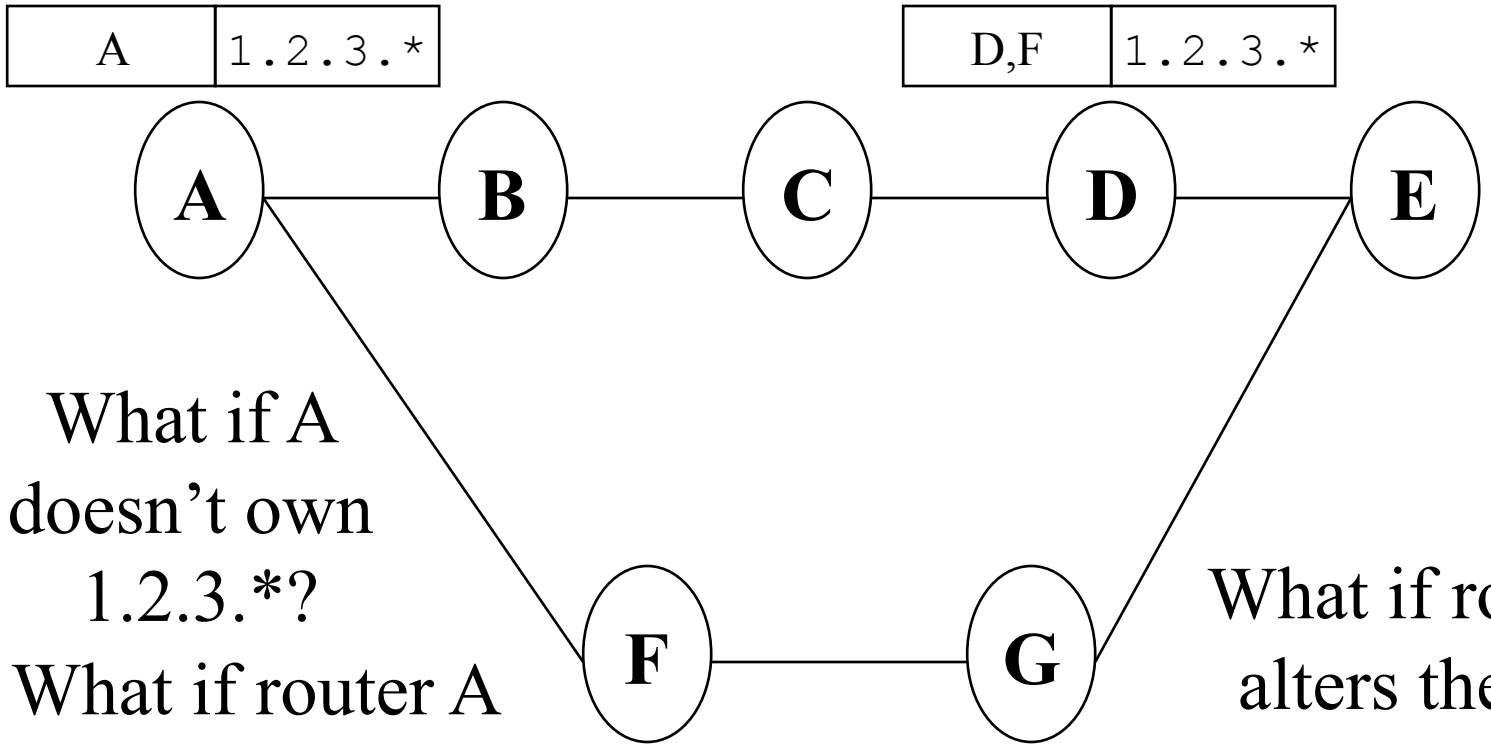
Basic BGP Security Issue



What do we need to protect?

A wants to tell everyone how to get to 1.2.3.*

Well, What Could Go Wrong?



What if A doesn't own 1.2.3.*?

What if router A isn't authorized to advertise 1.2.3.*?

What if router D alters the path?

Two Sub-Problems

- Security of Origin (SOA)
  - Who is allowed to advertise a path to an IP prefix?
- Path Validation (PV)
  - Is the path someone gives to me indeed a correct path?

How Do We Solve These Problems?

- SOA - Advertising routers must prove prefix ownership
  - And right to advertise paths to that prefix
- PV - Paths must be signed by routers on them
  - Must avoid cut-and-paste and replay attacks

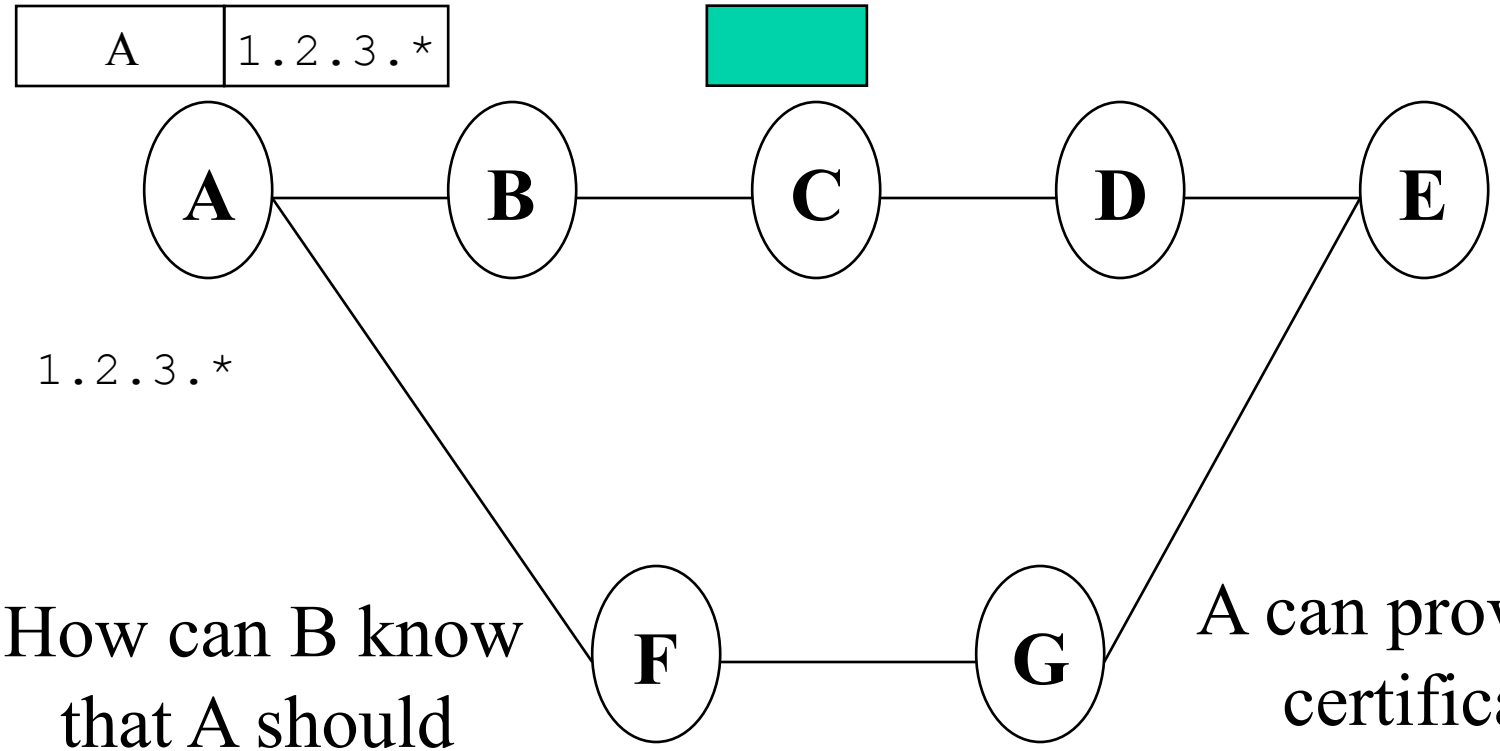
S-BGP

- One example solution
- A protocol designed to solve most of the routing security issues for BGP
- Intended to be workable with existing BGP protocol
- Key idea is to tie updates to those who are allowed to make them
  - And to those who build them

Some S-BGP Constraints

- Can't change BGP protocol
  - Or packet format
- Can't have messages larger than max BGP size
- Must be deployable in reasonable way

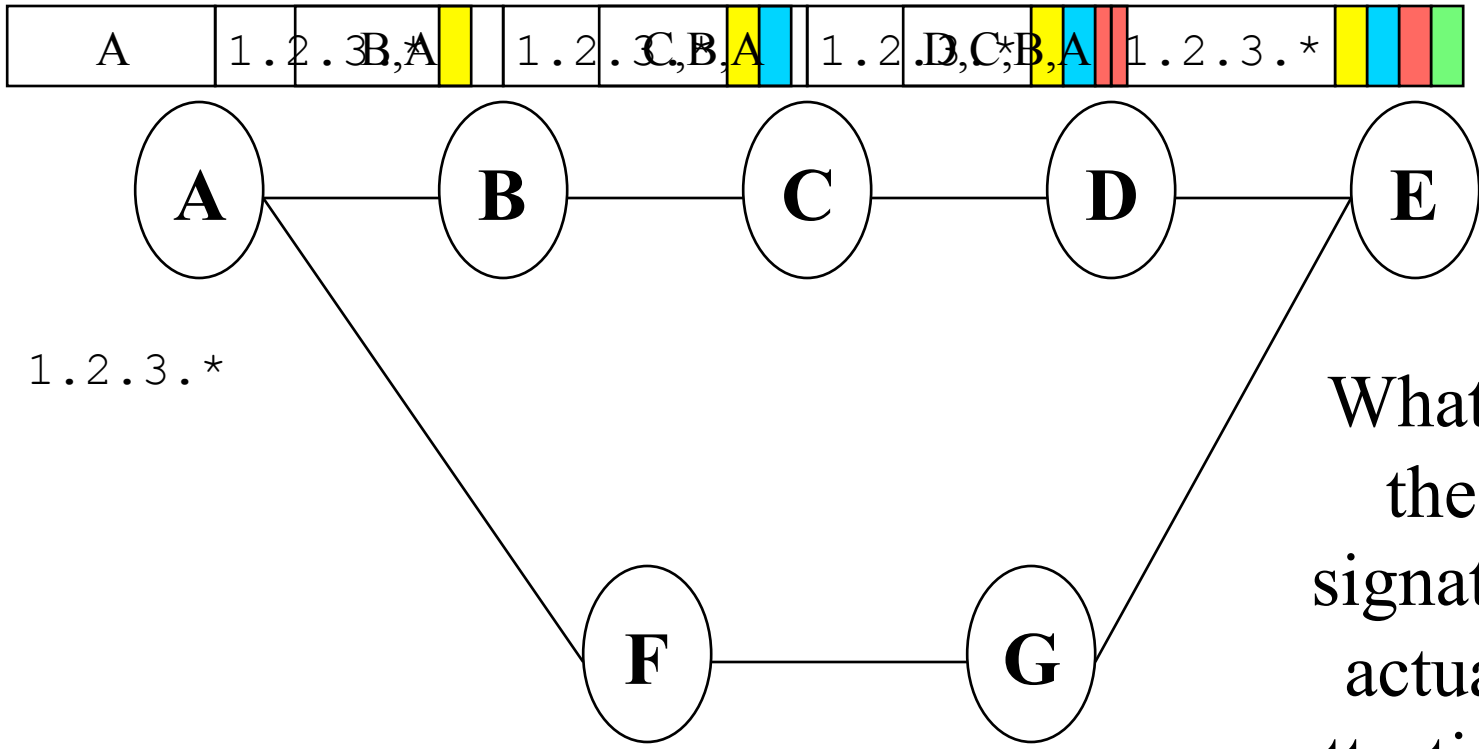
An S-BGP Example



How can B know that A should advertise 1.2.3.*?

A can provide a certificate proving ownership

Securing BGP Updates



What are these signatures actually attesting to?

A wants to tell everyone how to get to 1.2.3.*

Who Needs To Prove What?

- A needs to prove (to B-E) that he owns the prefix
- B needs to prove (to C-E) that A wants the prefix path to go through B
- C needs to prove (to D-E) the same
- D needs to prove (to E) the same

So What Does A Sign?

- A clearly must provide proof he owns the prefix
- He also must prove he originated the update
- And only A can prove that he intended the path to go through B
- So he has to sign for all of that

Address Attestations in S-BGP

- These are used to prove ownership of IP prefix spaces
- IP prefix owner provides attestation that a particular AS can originate its BGP updates
- That AS includes attestation in updates

Route Attestations

- To prove that path for a prefix should go through an AS
- The previous AS on the path makes this attestation
  - E.g., B attests that C is the next AS hop

How Are These Signatures Done?

- Via public key cryptography
- Certificates issued by proper authorities
  - ICANN at the top
  - Hierarchical below ICANN
- Certificates not carried with updates
  - Otherwise, messages would be too big
  - Off-line delivery method proposed

S-BGP and IPSec

- S-BGP generates the attestations itself
- But it uses IPSec to deliver the BGP messages
- Doing so prevents injections of replayed messages
- Also helps with some TCP-based attacks
  - E.g., SYN floods

S-BGP Status

- Not getting traction in networking community
- Probably not going to be the ultimate solution
- IETF working group is looking at various protocols with similar approaches

Other BGP Security Approaches

- Filter BGP updates from your neighbors
  - Don't accept advertisements for prefixes they don't own
  - Requires authoritative knowledge of who owns prefixes
- Use Resource PKI to distribute certificates on who owns what prefixes
- Sanity check routes
- Continuous monitoring of routing system