CS514: Intermediate Course in Operating Systems

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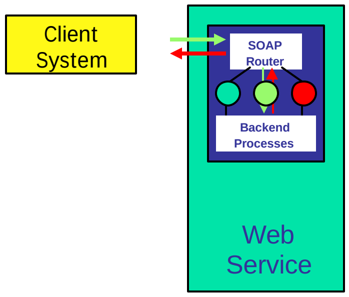
Today

- Web Services – Introduction
- “Remote Procedure Call” in WS
  - Binding, Marshalling…
- Using TCP as the transport for RPCs
  - Connectivity Issues: NAT, Firewall

What are Web Services?

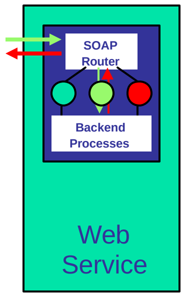
- Today, we normally use Web browsers to talk to Web sites
  - Browser names document via URL (lots of fun and games can happen here)
  - Request and reply encoded in HTML, using HTTP to issue request to the site
- Web Services generalize this model so that computers can talk to computers

What are Web Services?



What are Web Services?

- “Web Services are software components described via WSDL which are capable of being accessed via standard network protocols such as SOAP over HTTP.”



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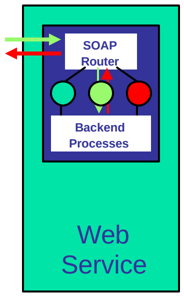
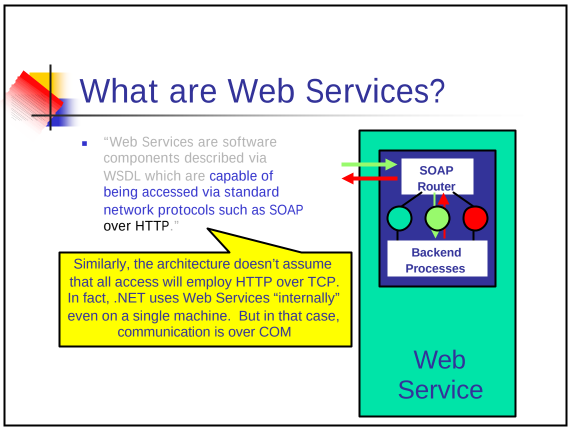
Today, SOAP is the primary standard. SOAP provides rules for encoding the request and its arguments.





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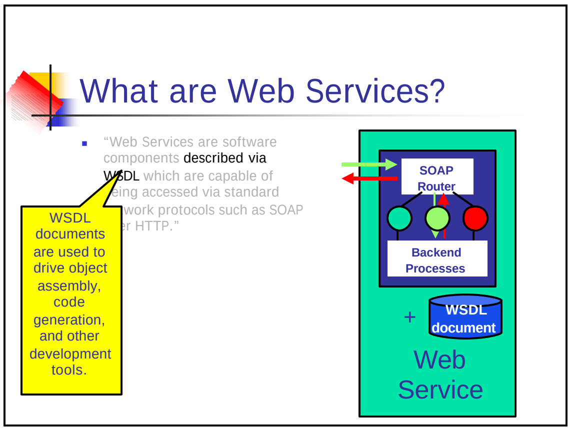
Similarly, the architecture doesn't assume that all access will employ HTTP over TCP. In fact, .NET uses Web Services "internally" even on a single machine. But in that case, communication is over COM



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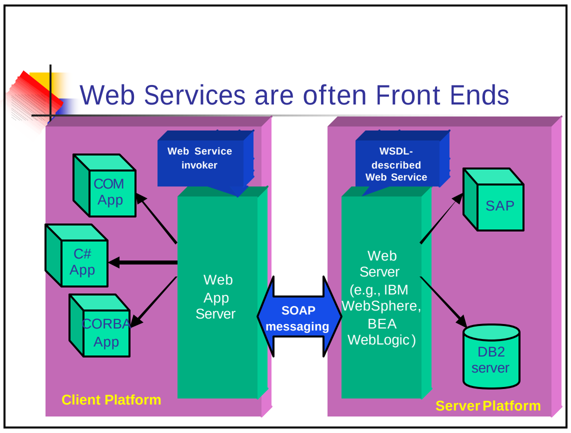
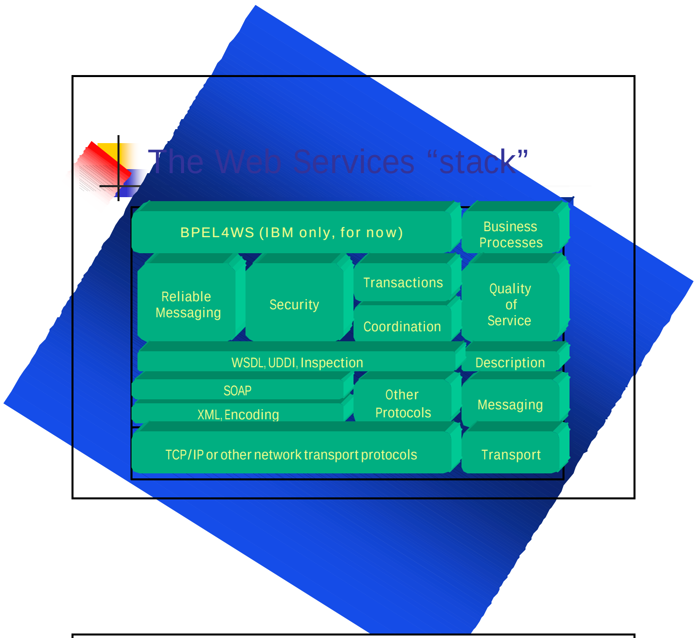
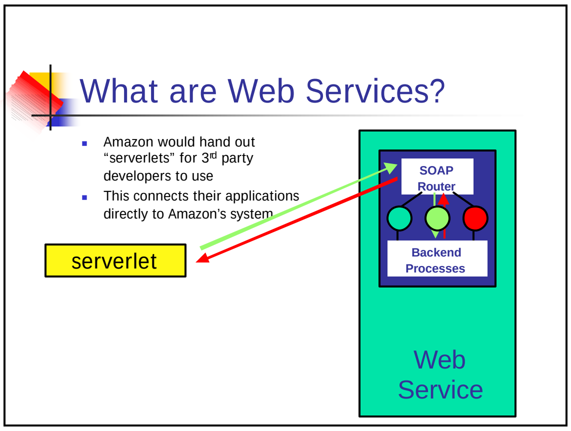
WSDL documents are used to drive object assembly, code generation, and other development tools.



Web Services are often Front Ends

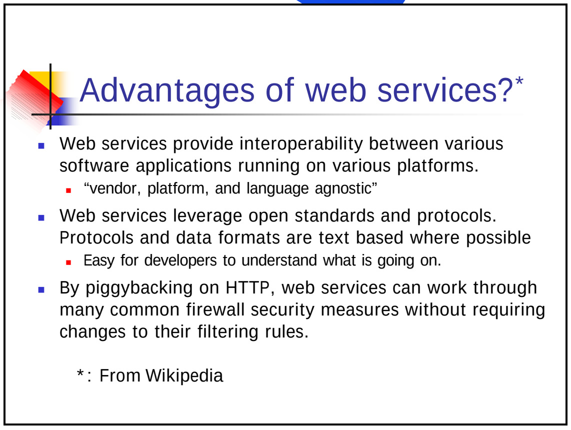


The Web Services "stack"



What are Web Services?

- Amazon would hand out "serverlets" for 3rd party developers to use
- This connects their applications directly to Amazon's system



Advantages of web services?*

- Web services provide interoperability between various software applications running on various platforms.
  - "vendor, platform, and language agnostic"
- Web services leverage open standards and protocols. Protocols and data formats are text based where possible
  - Easy for developers to understand what is going on.
- By piggybacking on HTTP, web services can work through many common firewall security measures without requiring changes to their filtering rules.

*: From Wikipedia

How Web Services work

- First the client *discovers* the service.
  - More in next lecture!
- Typically, client then *binds* to the server.
  - By setting up TCP connection to the discovered address .
  - But binding not always needed.

How it works…

- Next build the SOAP request: (*Marshaling*)
  - Fill in what service is needed, and the arguments. Send it to server side.
  - More details in next lecture
- SOAP router routes the request to the appropriate server(assuming more than one available server)
  - Can do load balancing here.

How it works…

- Server unpacks the request, (*Demarshaling*) handles it, computes result.
- Result sent back in the reverse direction: from the server to the SOAP router back to the client.

Marshalling Issues

- Data exchanged between client and server needs to be in a platform independent format.
  - “Endian”ness differ between machines.
  - Data alignment issue (16/32/64 bits)
  - Multiple floating point representations.
  - Pointers
  - ➢ (Have to support legacy systems too)

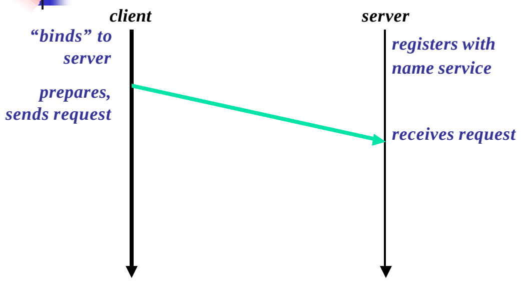
Marshalling…

- In Web Services, the format used is XML.
  - In UNICODE, so very verbose.
  - There are other, less general, but more efficient formats.

RPC – Remote Procedure Call

- Call a procedure on a remote machine “just” as you would on the local machine.
- Introduced by Birrell and Nelson in 1985
- Idea: mask distributed computing system using a “transparent” abstraction
  - Looks like normal procedure call
  - Hides all aspects of distributed interaction
  - Supports an easy programming model
- Today, RPC is the core of many distributed systems.
- Can view the WS client server interaction as an RPC.

The basic RPC protocol



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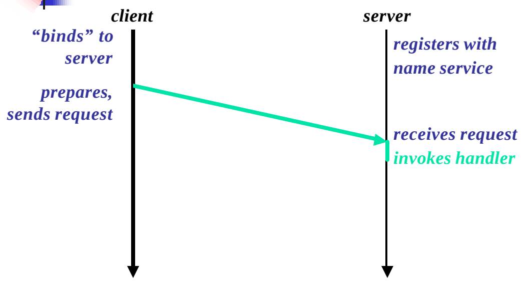

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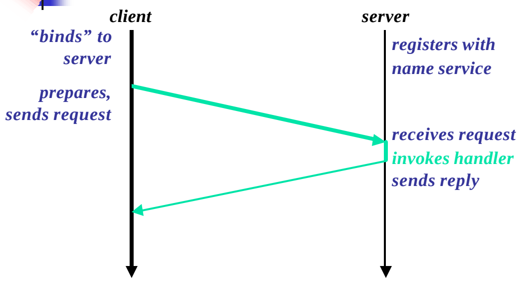

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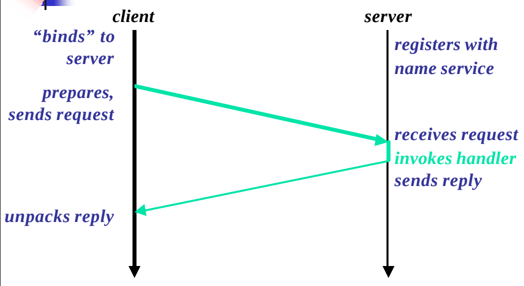


RPC – what can go wrong?

- Network failure, client failure, server failure
- Assuming only network idiosyncrasies for now...
- RPCs use acks to make packet transmission more reliable.
  - If timeout with no ack, resend packet.
  - Leads to the issue of replayed requests.
- Each packet has a sequence number and timestamp embedded to enable detection of duplicates.

RPC Optimization

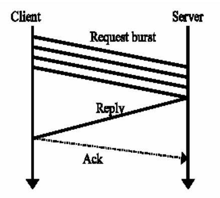


Figure 4.4. RPC using a burst protocol; here the reply is sent soon enough so that an acknowledgement to the burst is not needed.

- Delay sending acks, so that imminent reply itself acts as an ack.
- Don’t send acks after each packet.
- Send ack only at the end of transmission of entire RPC request.
- NACK sent when missing sequence number detected

What happens when machines could fail too?

- What does a failed request mean?
  - Network failure and/or machine failure!
  - Client that issued request would not know if the server processed the request or not.

How about layering RPC on TCP?

- TCP gives reliable in-order delivery, flow control and congestion control.
  - Reliable: Acknowledgments and retransmissions.
  - In-order: Sequence numbers embedded in each message.
  - Flow Control: Max allowed window size.

TCP...

- Congestion Control: the saw tooth curve
  - Ramp up as long as no timeouts.
    - Slow -start phase – exponential increase (until the slow-start threshold is hit)
    - Congestion Avoidance phase – additive increase
  - Multiplicative Decrease on timeout.

TCP optimizations

- Random Early Detection
- Selective Acknowledgments
- Fast Retransmit/Recovery

Back to RPC on TCP:

- Eg: Web Services, CORBA
- TCP gives reliable communication when both ends and the network connecting them are up.
- So the RPC protocol itself does not need to employ timeouts and retransmission.
  - Simpler RPC implementation.

RPC/TCP ...

- Does this mean RPC got more reliable by using TCP?
- NO, since broken connections reported by TCP mean the same thing they did earlier (without TCP)
  - Client still doesn't know whether the server processed its request.
- No standard way of handling timeouts.

RPC Semantics

- "Exactly Once"
  - Each request handled exactly once.
  - Impossible to satisfy, in the face of failures.
  - Can't tell whether timeout was because of node failure or communication failure.

RPC Semantics…

- "At most Once"
  - Each request handled at most once.
  - Can be satisfied, assuming synchronized clocks, and using timestamps.
- "At least Once"
  - If client is active indefinitely, the request is eventually processed (maybe more than once)

WS & RPC Connectivity Issues: Network Address Translation

- IP Address – 32 bits only.
  - Address Space Shortage.
- NATs invented to overcome this problem.
- Have a NAT box in between a private network and the internet.
- Can use locally allocated addresses within private network.
- The NAT router maps the internal IP address:port to the external IP address:port and vice-versa.

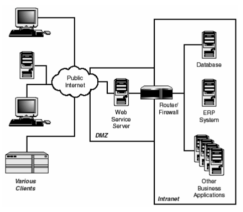
NAT…

- The internal address is not addressable from outside.
  - A measure of security.
  - If RPC server is behind a NAT, trouble!
    - NAT needs the host behind it to start the connection process.
    - Need to configure NAT to let specified traffic through.
    - Generally: (WS traffic)HTTP is let through.
  - Tough to have a connection in between two hosts behind NATs.
    - There are some tricks to bypass this though.

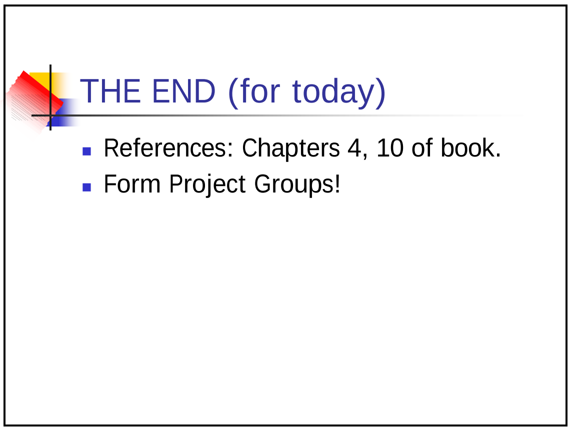
Firewall

- Allow/disallow traffic, depending on source, destination, protocol used, etc.
- Stateful: remember active flows, and disallow unexpected packets (NAT)
  - Again, need to configure to ensure server traffic gets through. (General RPC)
  - Again, (WS)HTTP does not face as much of a restriction.
- Get traffic statistics.
- Spam/virus checking, etc.
- NAT and firewall typically in the same box.

Demilitarized Zone (DMZ)



- DMZ: used to host publicly accessible services like company webpages, ftp, dns.
- Good place to host the Web Service!
- DMZ situated outside the private network.
- No outgoing connections from DMZ.
- If DMZ attacked, damage limited to DMZ.



THE END (for today)

- References: Chapters 4, 10 of book.
- Form Project Groups!