CS 4350: Fundamentals of Software Engineering
CS 5500: Foundations of Software Engineering

Lesson 3.3: REST Protocols

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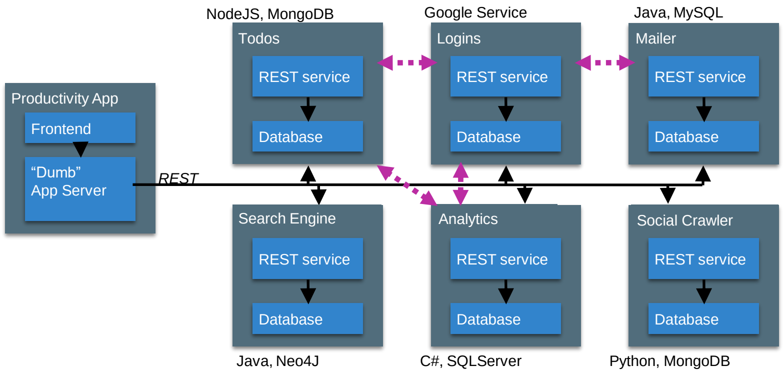
Learning Objectives for this Lesson

- By the end of this lesson you should be able to:
  - Explain the basic principles of RESTful protocols
  - Examine a protocol and suggest ways in which it either adheres to or violates the REST principles.

Your app relies on other apps for services

- Authentication (Login with Google/Apple/Facebook)
- Sending/receiving email (SendGrid, MailGun, MailChimp)
- Telephony, text messaging, video chat (Twilio)

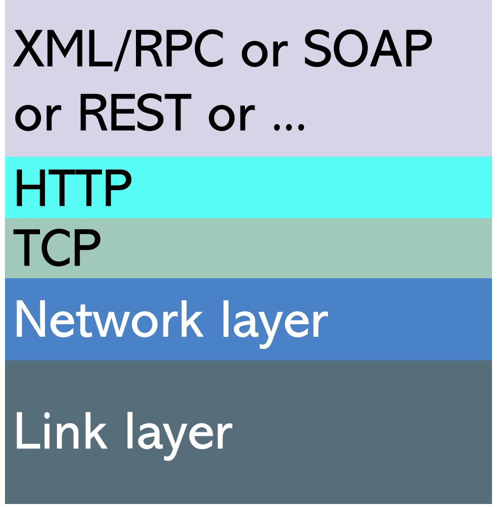


Obstacles to magic RPC

- transmission delays (latency)
- can the client do something useful in the meantime?
    - asynchrony
    - "mask latency with multiprocessing" → complexity
- client/server mismatch
    - different languages,
    - different data representations
    - wire-transmission formats
    - → more complexity

A Solution(?): use the web!

- Implement your protocol via http.
- Of course, then you have to define your protocol
- You'll want to define it in some standard metalanguage, so client and server can agree on its meaning.
- But that means the client-human and server-human have to agree on a standard metalanguage
- Lots of choices: XML/RPC, SOAP, WSDL, or ...



XML/RPC or SOAP or REST or …

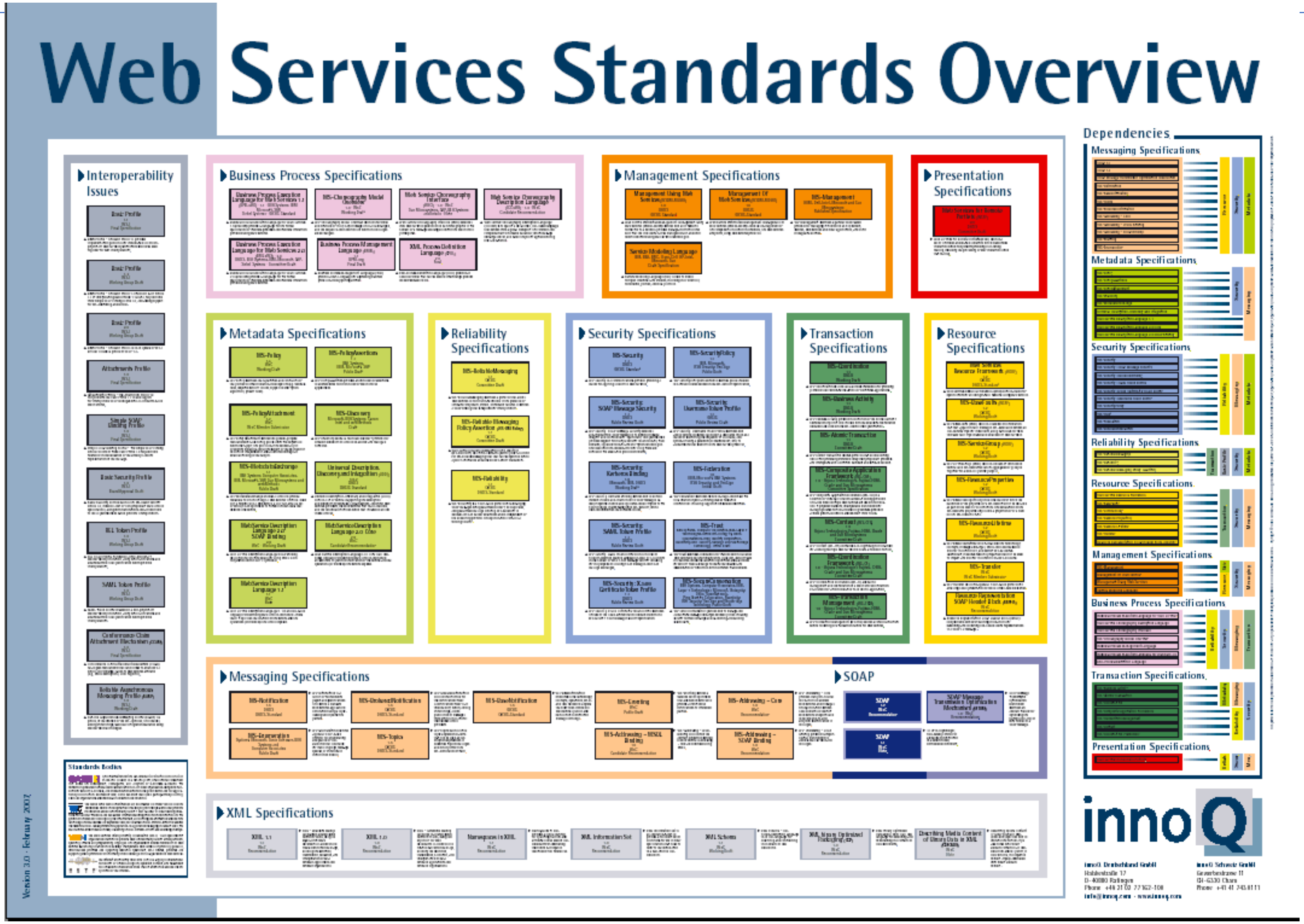
HTTP

TCP

Network layer

Link layer

Aagh!


Web Services Standards Overview
Interoperability Issues
Business Process Specifications
Management Specifications
Presentation Specifications
Metadata Specifications
Reliability Specifications
Security Specifications
Transaction Specifications
Resource Specifications
Messaging Specifications
SOAP
XML Specifications
Standards Bodies
Dependencies
Messaging Specifications
Metadata Specifications
Security Specifications
Reliability Specifications
Resource Specifications
Management Specifications
Business Process Specifications
Transaction Specifications
Presentation Specifications
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Now take a deep breath, and start again...

Remember we said:
Server interprets the Request

- This request probably started out as http://www.nowhere123.com/docs/index.html
- www.nowhere123.com identifies the server
- the rest of the request is the path, here /docs/index.html
- this might be a path in the server's file system,
- OR it could be anything at all—
- it's entirely up to the server to interpret the path

We'll see later how these paths are interpreted in REST protocols.

```
GET /docs/index.html HTTP/1.1
Host: www.nowhere123.com
Accept: image/gif, image/jpeg, */*
Accept-Language: en-us
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)
(blank line)
```

That means the client can ask the server to do things other than retrieve files

- Just has to be an agreement (a protocol) between client and server about how these tasks are to be described.
- Need a general framework to help us design such protocols.
- We will talk about one such philosophy, called REST

REST: Representational State Transfer

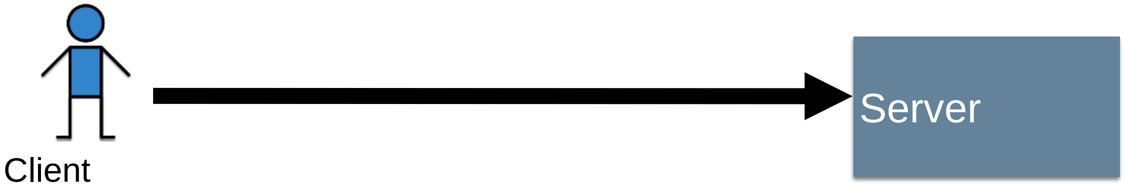
- Defined by Roy Fielding in his 2000 Ph.D. dissertation
- "Throughout the HTTP standardization process, I was called on to defend the design choices of the Web. That is an extremely difficult thing to do... I had comments from well over 500 developers, many of whom were distinguished engineers with decades of experience. That process honed my model down to a core set of principles, properties, and constraints that are now called REST."
- Not just a transport protocol, not a protocol definition language: a design philosophy
- Interfaces that follow REST principles are called RESTful

REST Principles

- Client/Server
  - Client calls server, server responds. That's it.
  - Separation of concerns: client doesn't worry about data, server doesn't worry about UI
- Uniform Interface
  - associate resources with URIs
- Statelessness
  - Each client request must contain all the information the server needs to process the request
  - No session state in the server!
- Client Sees Only a Single Server
  - server may pass request on to other machines, transparently to client
- Uniform Cacheability
  - responses must classify themselves as cacheable or not, so the client won't reuse stale data.

Client/Server

- Server is abstracted as a single box
- Client calls the server, server doesn’t call the client
- Enables separation of concerns:
  - Client doesn’t worry about databases, etc.
  - Server doesn't worry about UI

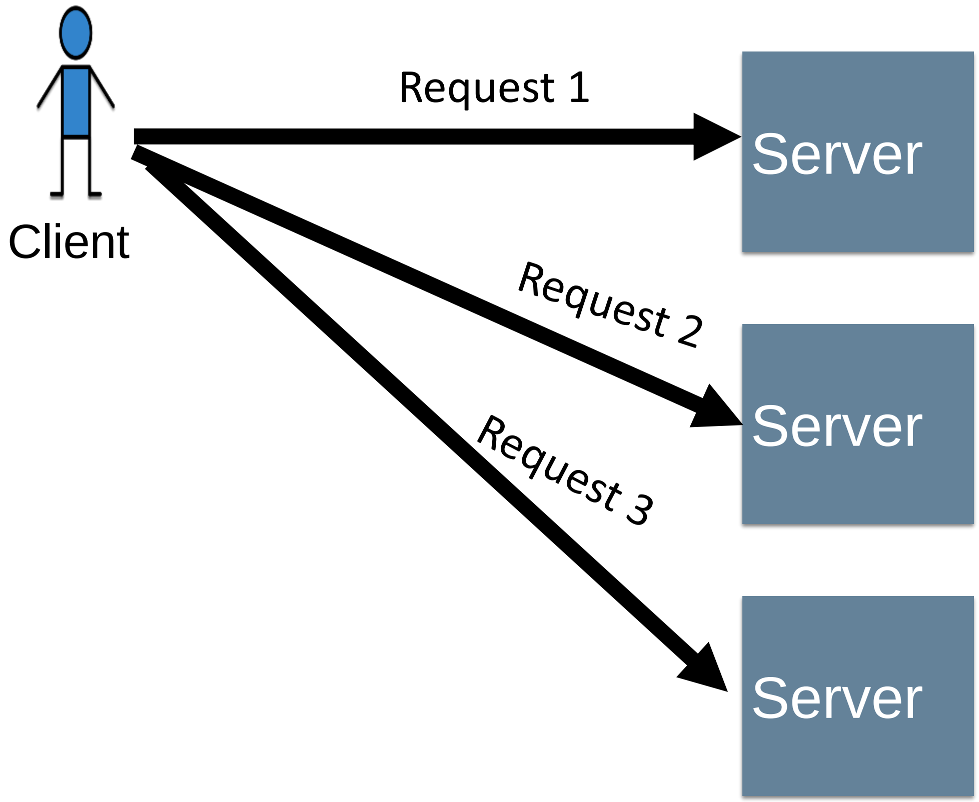


Uniform Interface

- URIs should hierarchically identify **nouns** describing resources that exist
- Verbs describing actions that can be taken with resources should be described with an HTTP action
  - more on this later

Statelessness

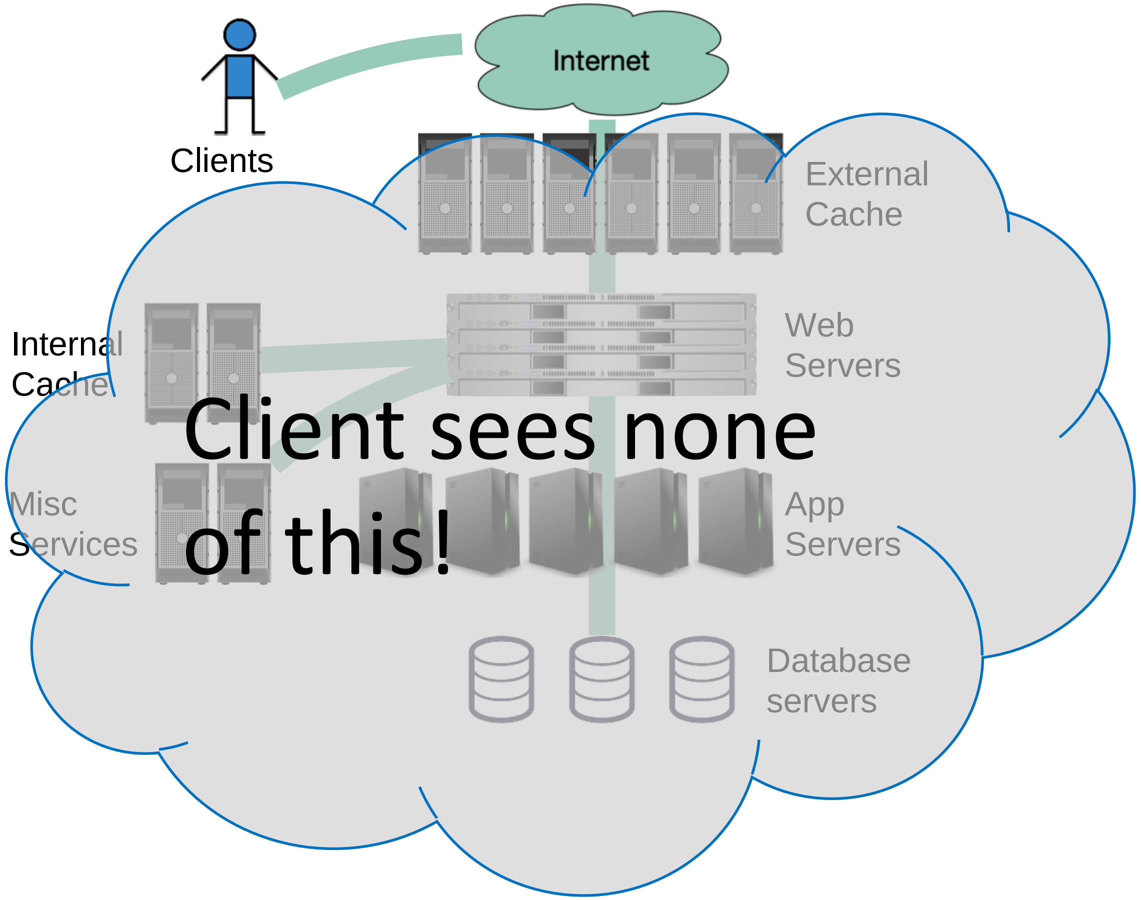
- Each client request contains all information necessary to service the request
  - The client doesn't have to write a sequence of requests to get their work done.
  - So requests can be farmed out to different servers



Client sees only a single server

- Enables flexible design: different servers can have different responsibilities, client sees just a single server

For the time being, our examples will only have one layer, so you don't have to worry about this immediately.

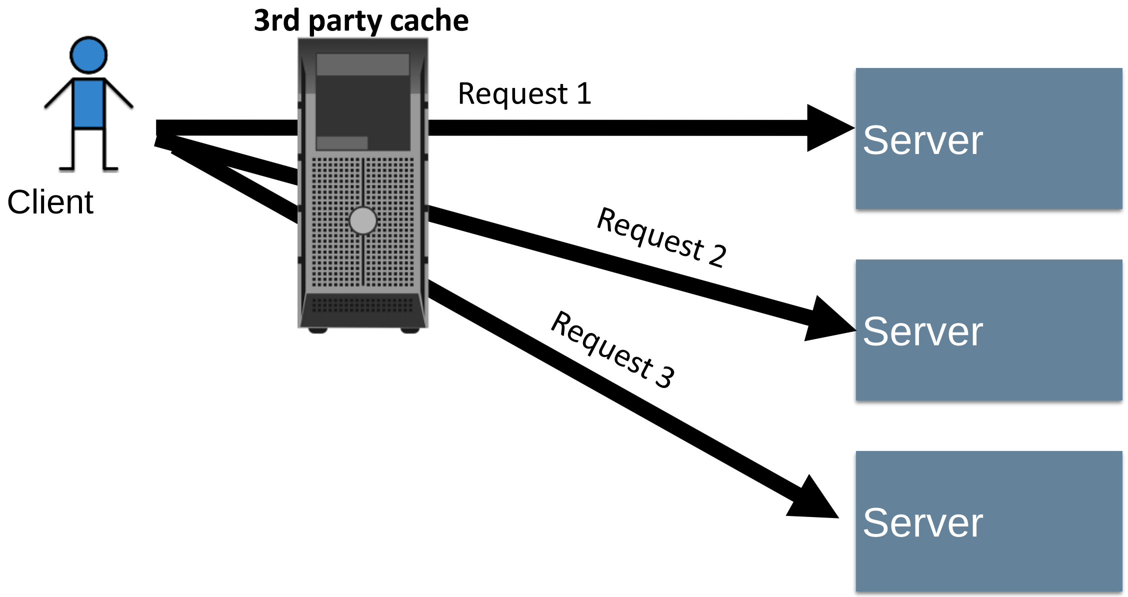


Client sees none of this!

Uniform cacheability

- Requests and responses are clearly classified as cacheable or not
- Enables use of generic caches that don't know **anything** about the structure of what they cache - just what can be cached

This involves more systems stuff than we will normally get involved with, so you don't have to worry about this immediately.



Back to Uniform Interface: Nouns are represented as URIs

- In a RESTful system, the server is visualized as a store of resources (nouns), each of which has some data associated with it.
- URIs represent these resources
- Examples:
  - `/cities/losangeles`
  - `/transcripts/00345/graduate` (student 00345 has several transcripts in the system; this is the graduate one)
- Anti-examples:
  - `/getCity/losangeles`
  - `/getCitybyID/50654`
  - `/Cities.php?id=50654`

Useful heuristic: if you were keeping this data in a bunch of files, what would the directory structure look like?

Verbs are represented as http methods

- In REST, there are four things you can do with a resource
- POST: requests the server to create a resource
  - there are several ways in which the value for the new resource can be transmitted (more In a minute)
- GET: requests the server to respond with a representation of the resource
- PUT: requests the server to replace the value of the resource by the given value
- DELETE: requests the server to delete the resource

You say you want parameters?

There are at least 3 ways to associate parameters with a request:

- path parameters. These specify portions of the path to the resource. For example, your REST protocol might allow a path like

```
/transcripts/00345/graduate
```

- query parameters. These are part of the URI and are typically used as search items. For example, your REST protocol might allow a path like

```
/transcripts/graduate?lastname=covey&firstname=avery
```

- body parameters. These are like query parameters, except that they are placed in the first line of the body. This is typically done only for POST or PUT requests.

Example interface #1: a todo-list manager

- Resource: /todos
  - GET /todos   - get list all of my todo items
  - POST /todos - create a new todo item (data in body)
- Resource: /todos/:todoItemID
  - :todoItemID is a path parameter
  - GET /todos/:todoItemID - fetch a single item by id
  - PUT /todos/:todoItemID - update a single item (new data in body)
  - DELETE /todos/:todoItemID - delete a single item

Example Interface #2: a database of transcripts

```
POST /transcripts
 -- adds a new student to the database,
 -- returns an ID for this student.
 -- requires a body parameter 'name'.
 -- Multiple students may have the same name.
GET  /transcripts/:ID
 -- returns transcript for student with given ID.  Fails if no such student
DELETE /transcripts/:ID
 -- deletes transcript for student with the given ID, fails if no such student
POST /transcripts/:studentID/:courseNumber
 -- adds an entry in this student's transcript with given name and course.
 -- Requires a body parameter 'grade'.
 -- Fails if there is already an entry for this course in the student's transcript
GET  /transcripts/:studentID/:courseNumber
 -- returns the student's grade in the specified course.
 -- Fails if student or course is missing.
GET  /studentids?name=string
 -- returns list of IDs for student with the given name
```

Useful heuristic: if you were keeping this data in a bunch of files, what would the directory structure look like?

Didn't seem to fit the model, sorry ☹

Review: Learning Objectives for this Lesson

- You should now be able to:
    - Explain the basic principles of RESTful protocols
    - Examine a protocol and suggest ways in which it either adheres to or violates the REST principles.

Next steps...

- In our next lesson, we'll build a server for the transcript protocol, using express.js.