

# [544] gRPC and Docker Compose

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# Learning Objectives

- describe the functionality that HTTP provides (beyond what TCP alone provides)
- call functions remotely via gRPC
- configure SSH tunneling and Docker port forwarding to communicate with an app in a container on a different machine
- deploy multi-container apps with Docker compose

# Outline

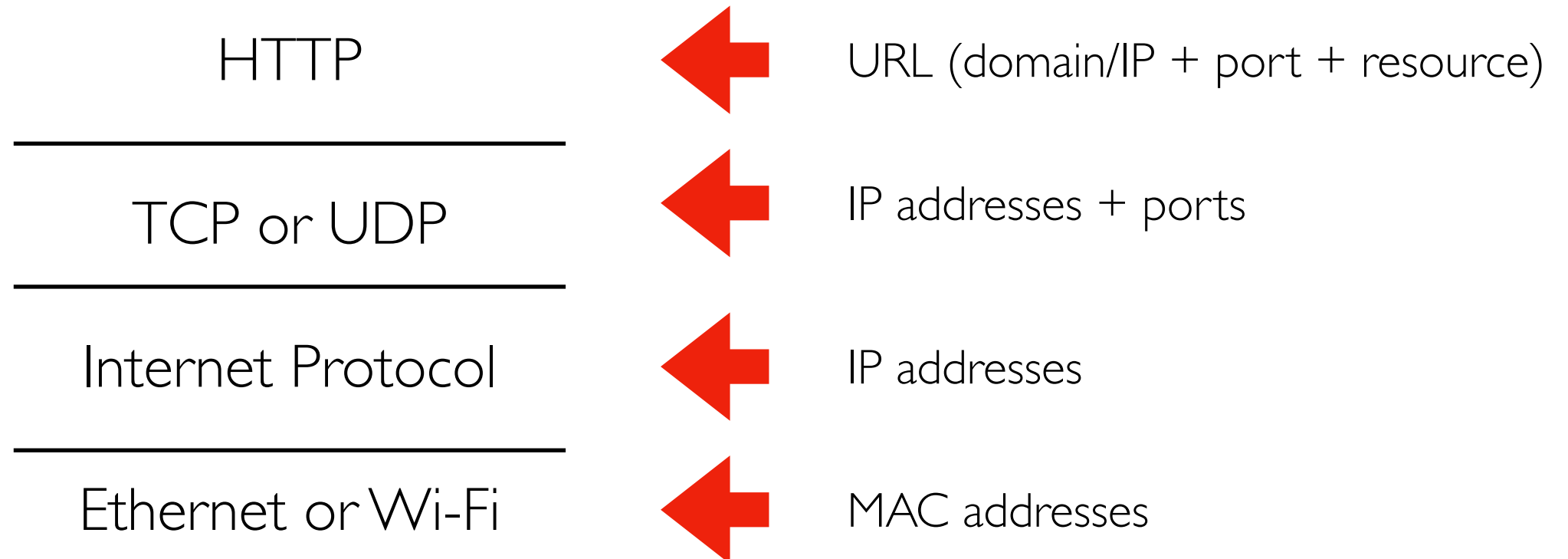
HTTP

gRPC

Docker Port Forwarding

Docker Compose

# HTTP (Hypertext Transfer Protocol)



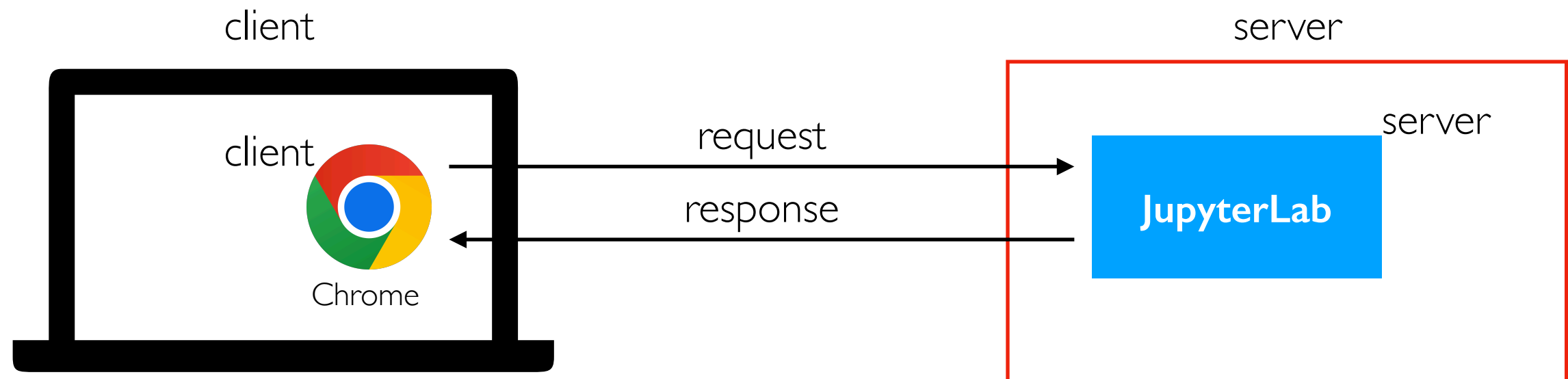
`https://tyler.caraza-harter.com:443/cs544/f24/schedule.html`

**domain name**  
(mapped to an IP)

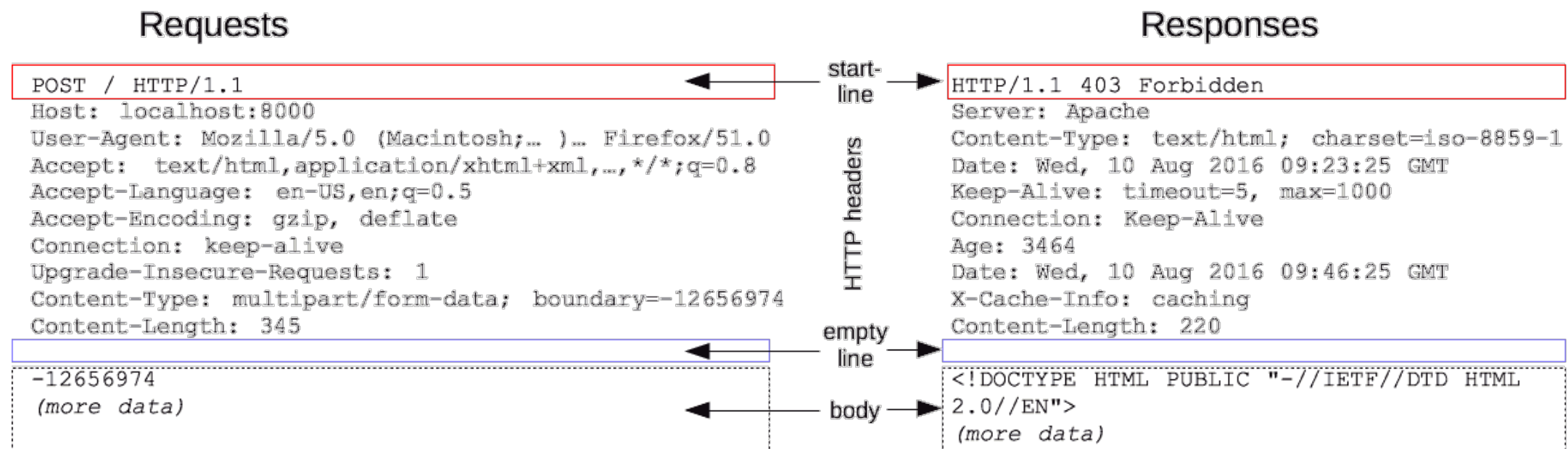
**port**  
(443 is default  
for https)

**resource**

# HTTP Messages Between Clients and Servers



Parts: method, resource, status code, headers, body



<https://developer.mozilla.org/en-US/docs/Web/HTTP/Messages>

# HTTP Methods (types of messages)

Types of request

- **POST**: create a new resource (request+response have body)
- **PUT**: update a resource (request+response have body, usually)
- **GET**: fetch a resource (response has body)
- **DELETE**: delete a resource
- others...

Canvas **REST** API example:

GET <https://canvas.wisc.edu/api/v1/conversations>  
(see all Canvas conversations in JSON format)

POST <https://canvas.wisc.edu/api/v1/conversations>  
(create new Canvas conversation)

<https://canvas.instructure.com/doc/api/conversations.html>

# Outline

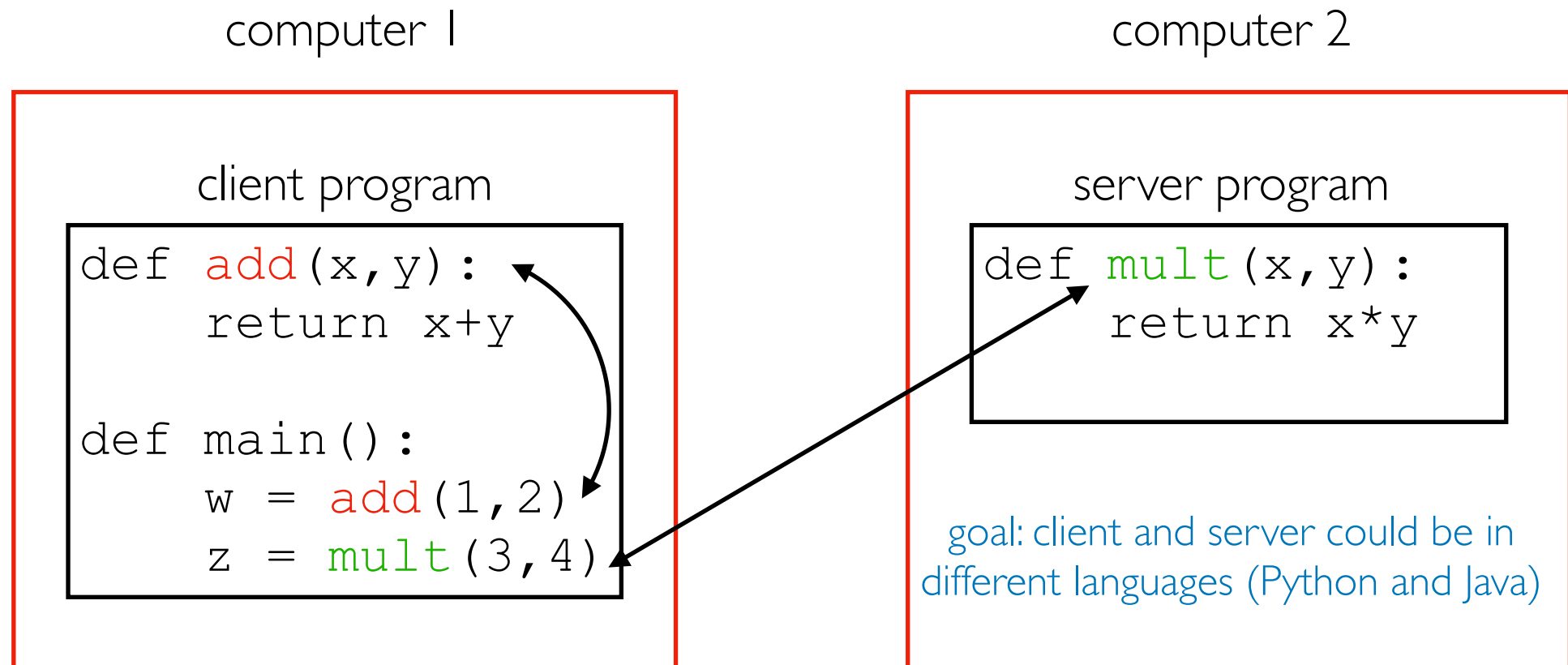
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# Remote Procedure Calls (RPCs)



procedure = function

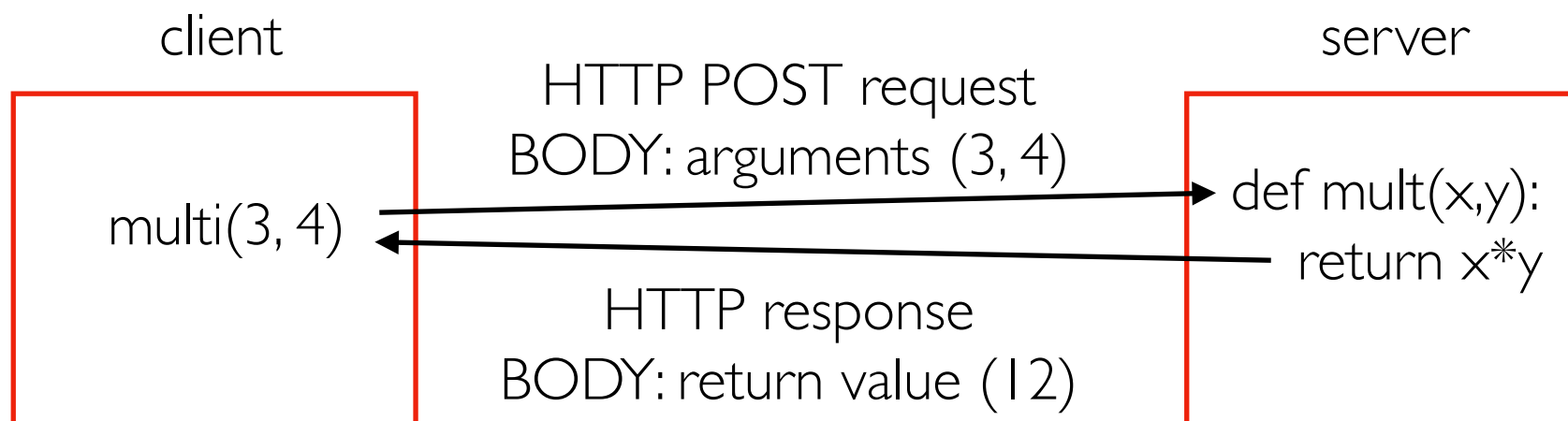
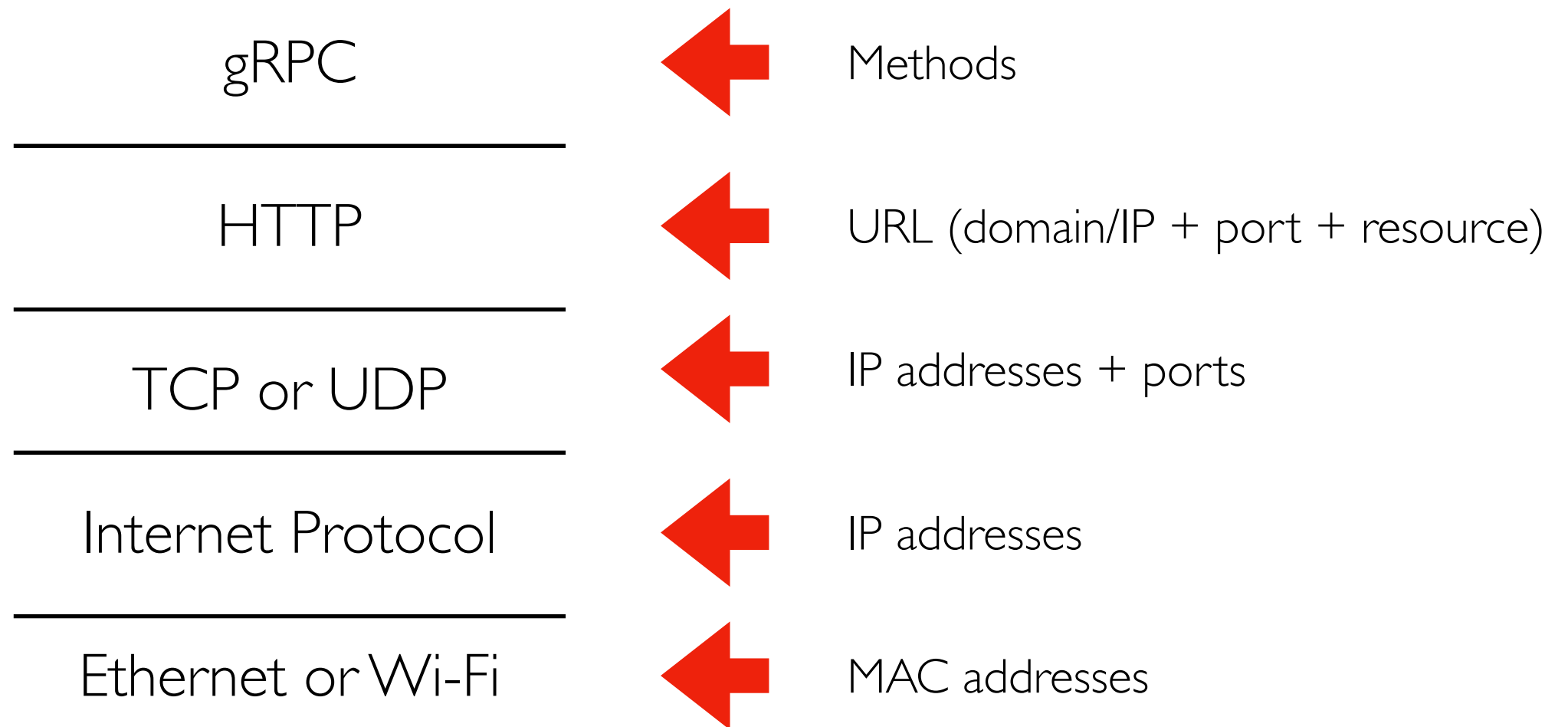
- **main** calling **add** is a regular procedure call
- **main** call **mult** is a remote procedure call

There are MANY tools to do RPCs

- Thrift (developed at Meta)
- gRPC (developed at Google) -- this semester



# gRPC builds on HTTP



# Serialization/deserialization (Protobufs)

*How do we represent arguments and return values as bytes in a request/response body?*

**Serialization:** various types (ints, strs, lists, etc) to **bytes** ("wire format")

**Deserialization:** **bytes** to various types

**Challenge 1:** every language has different types and we want cross-languages calls

gRPC uses Google's **Protocol Buffers** provide a uniform type system across languages.

**Challenge 2:** different CPUs order bytes differently

cpu A int32: 

byte 1	byte 2	byte 3	byte 4
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cpu B int32: 

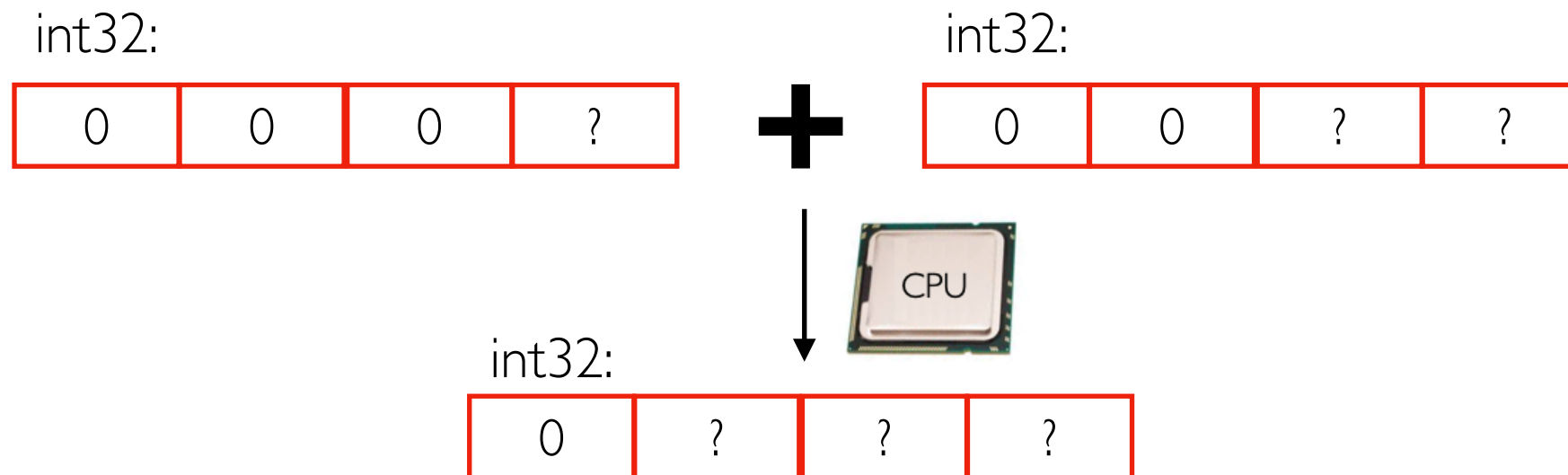
byte 4	byte 3	byte 2	byte 1
--------	--------	--------	--------

*Equivalent with digit order: "twelve" is "12" by convention, but people could have chosen "21" to mean "twelve"*

.proto	C++	Java	Python
double	double	double	float
float	float	float	float
int32	int32	int	int
int64	int64	long	int
uint32	uint32	int	int
uint64	uint64	long	int
sint32	int32	int	int
sint64	int64	long	int
bool	bool	boolean	bool
string	string	String	str
bytes	string	ByteString	bytes

<https://protobuf.dev/programming-guides/proto/>

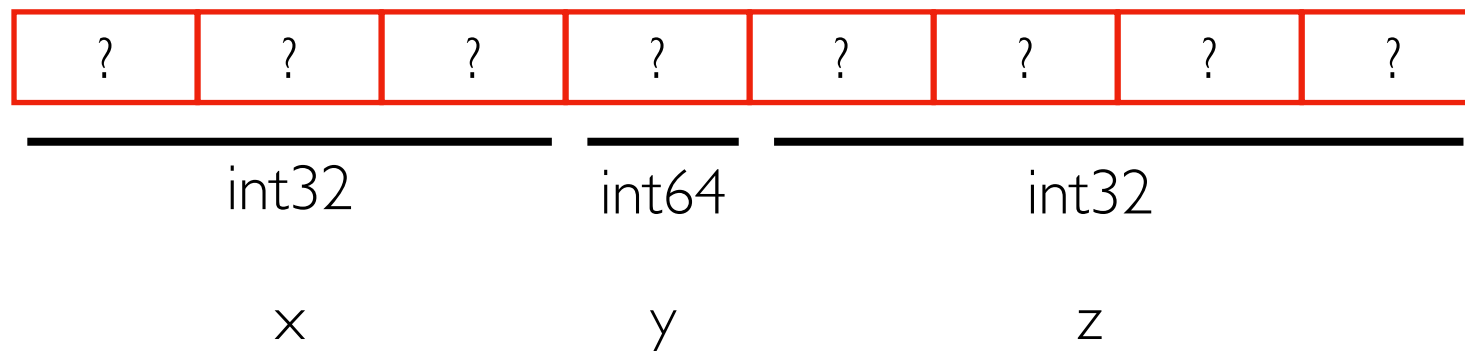
# Variable-Length Encoding



For **computational efficiency**, int32's use 4 bytes during computation. Also helps w/ offsets.

For **space efficiency**, smaller numbers in int32s could use fewer bytes (4 bytes is max). This reduces network traffic.

Example nums in a protobuf:



Demos...

# Outline

HTTP

gRPC

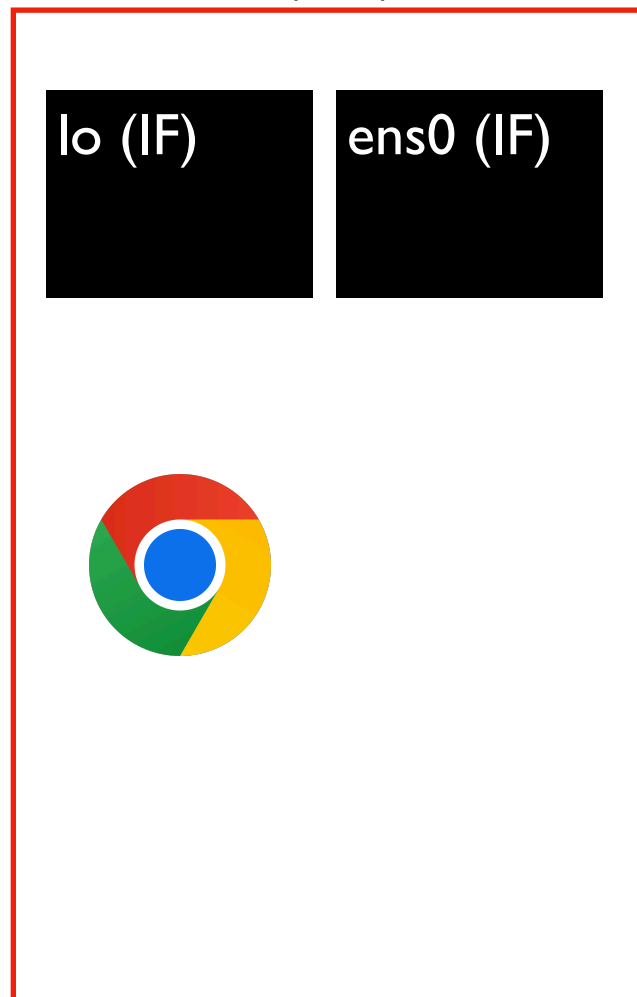
Docker Port Forwarding

Docker Compose

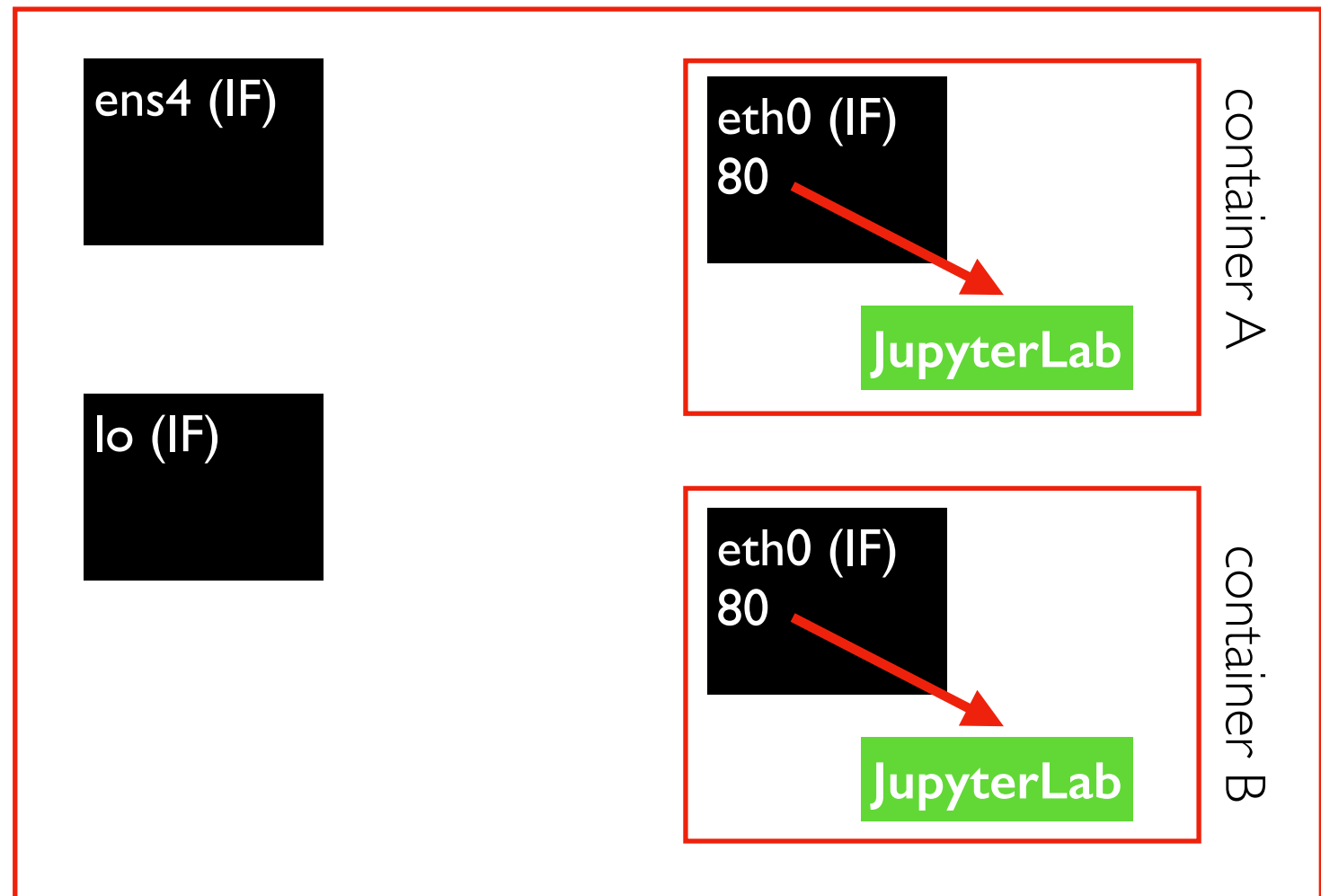
# Interfaces (IF) and Ports

both containers have  
a virtual port 80

laptop

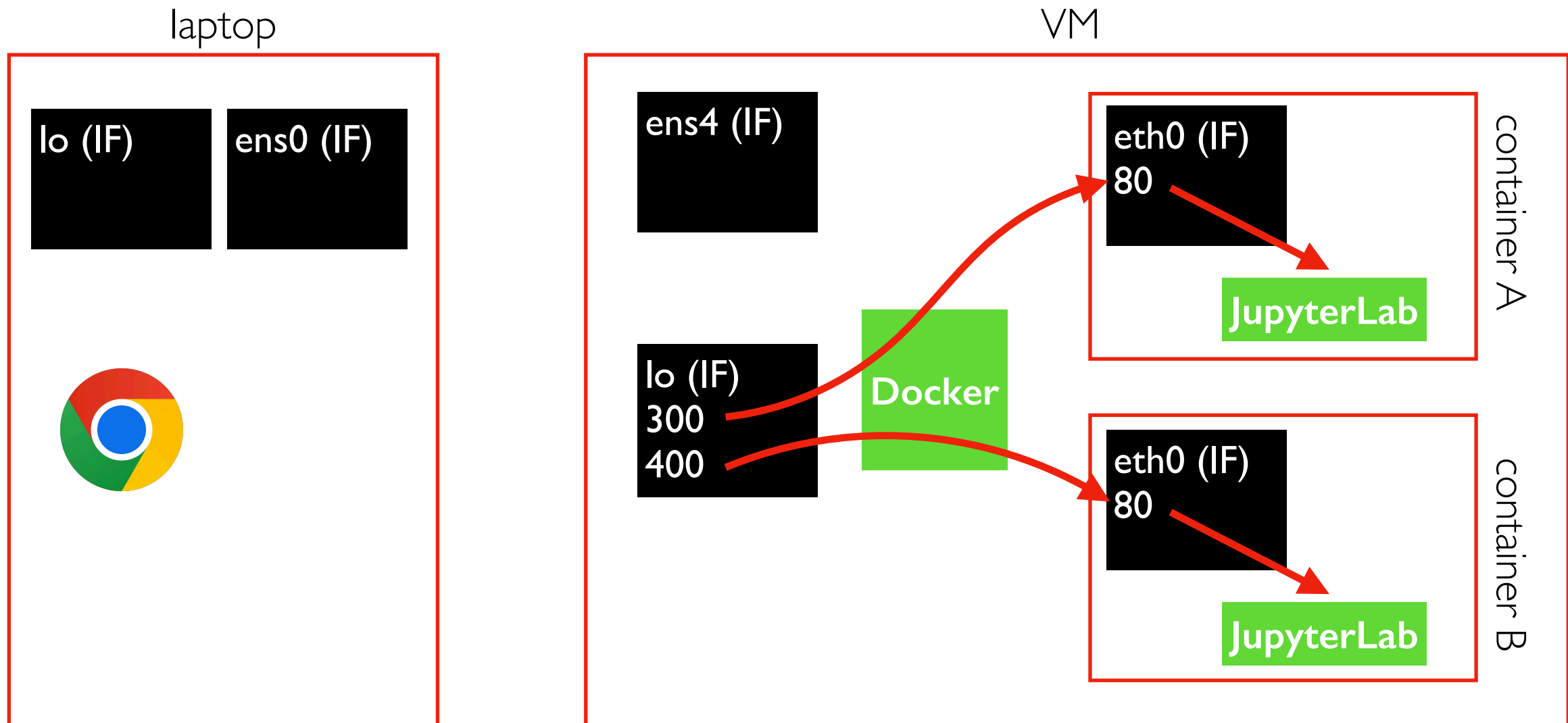


VM



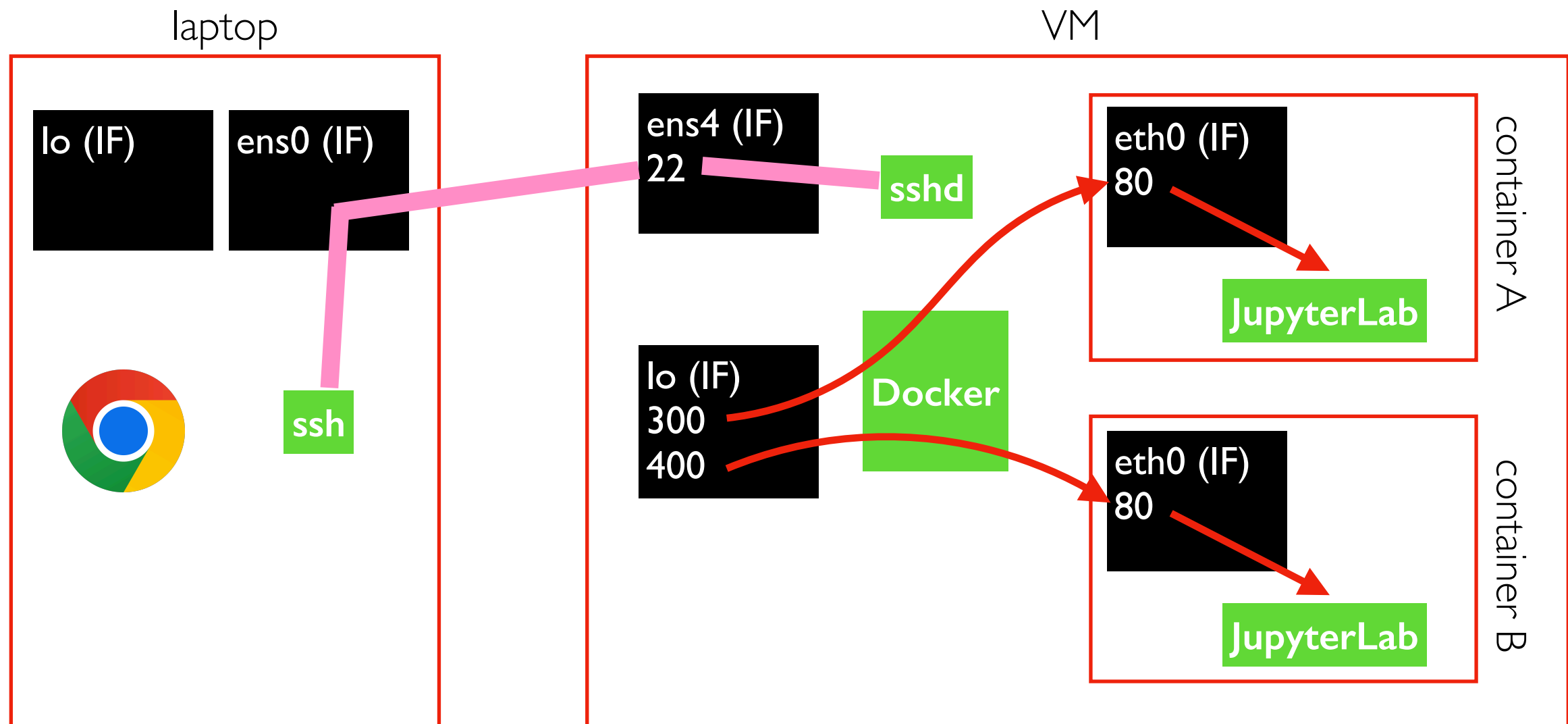
```
docker run -d myimg  
docker run -d myimg
```

# Interfaces (IF) and Ports



```
docker run -d -p 127.0.0.1:300:80 myimg  
docker run -d -p 127.0.0.1:400:80 myimg
```

# Interfaces (IF) and Ports



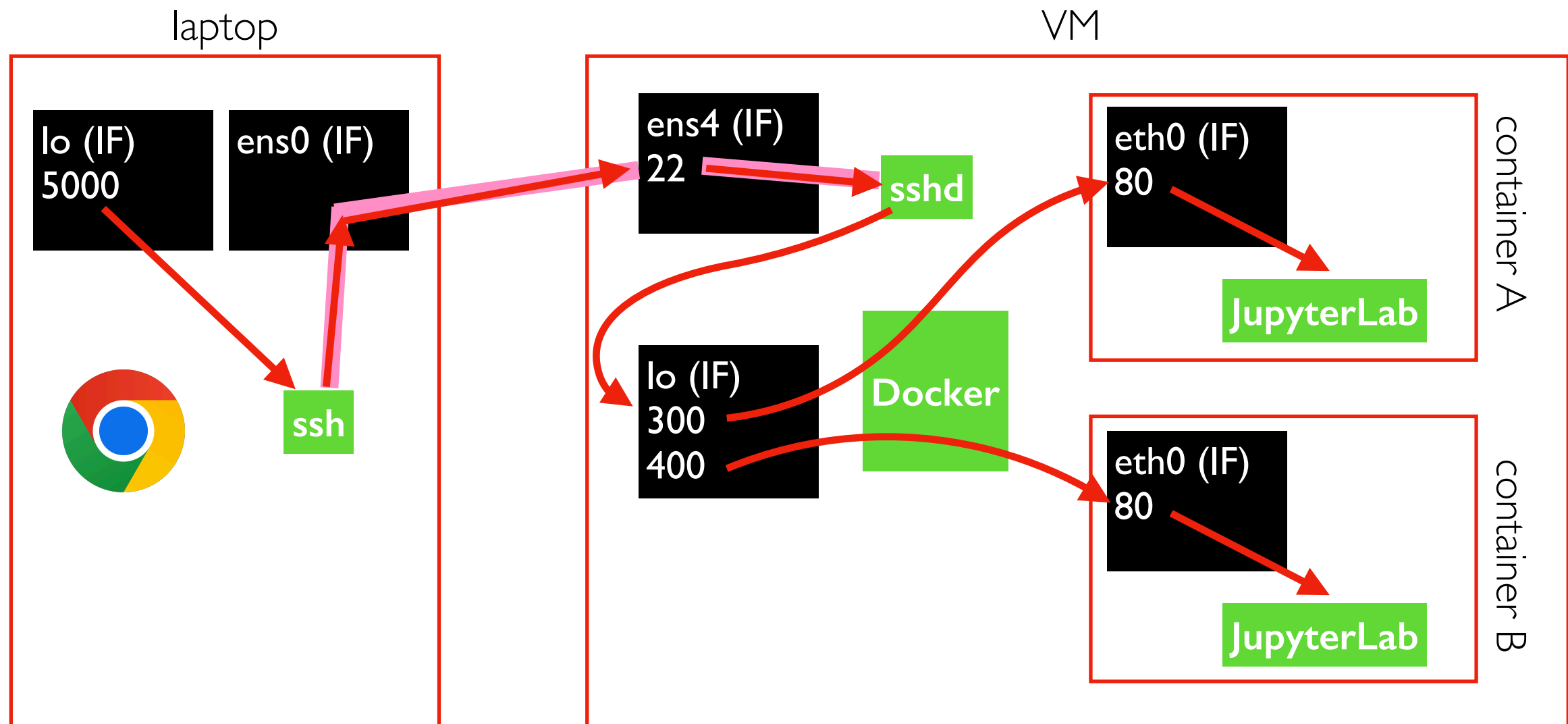
```
ssh USER@VM
```

```
docker run -d -p 127.0.0.1:300:80 myimg  
docker run -d -p 127.0.0.1:400:80 myimg
```

the SSH connection can be used to send commands and/or forward network traffic



# Interfaces (IF) and Ports

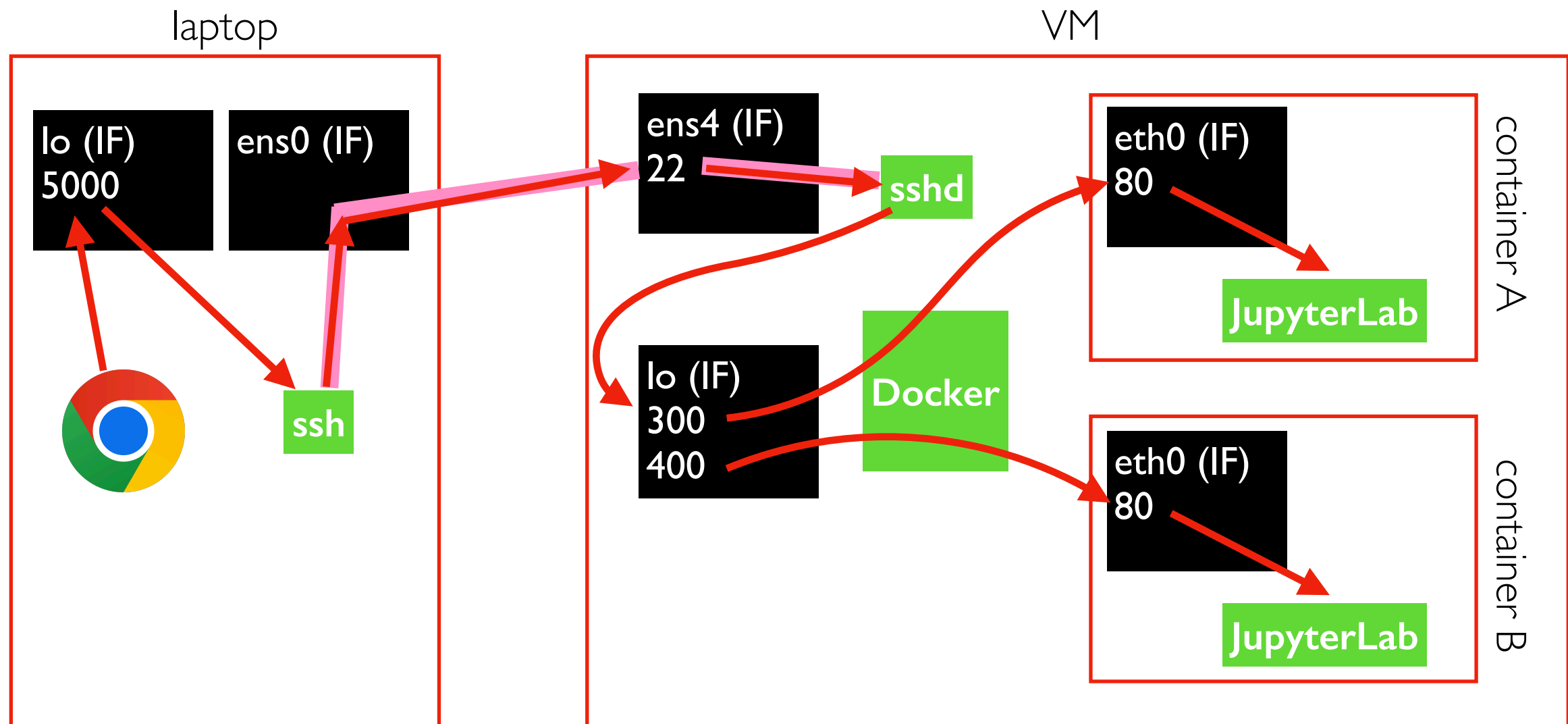


```
ssh USER@VM -L localhost:5000:localhost:300
```

```
docker run -d -p 127.0.0.1:300:80 myimg  
docker run -d -p 127.0.0.1:400:80 myimg
```

the SSH connection can be used to send commands and/or forward network traffic

# Interfaces (IF) and Ports

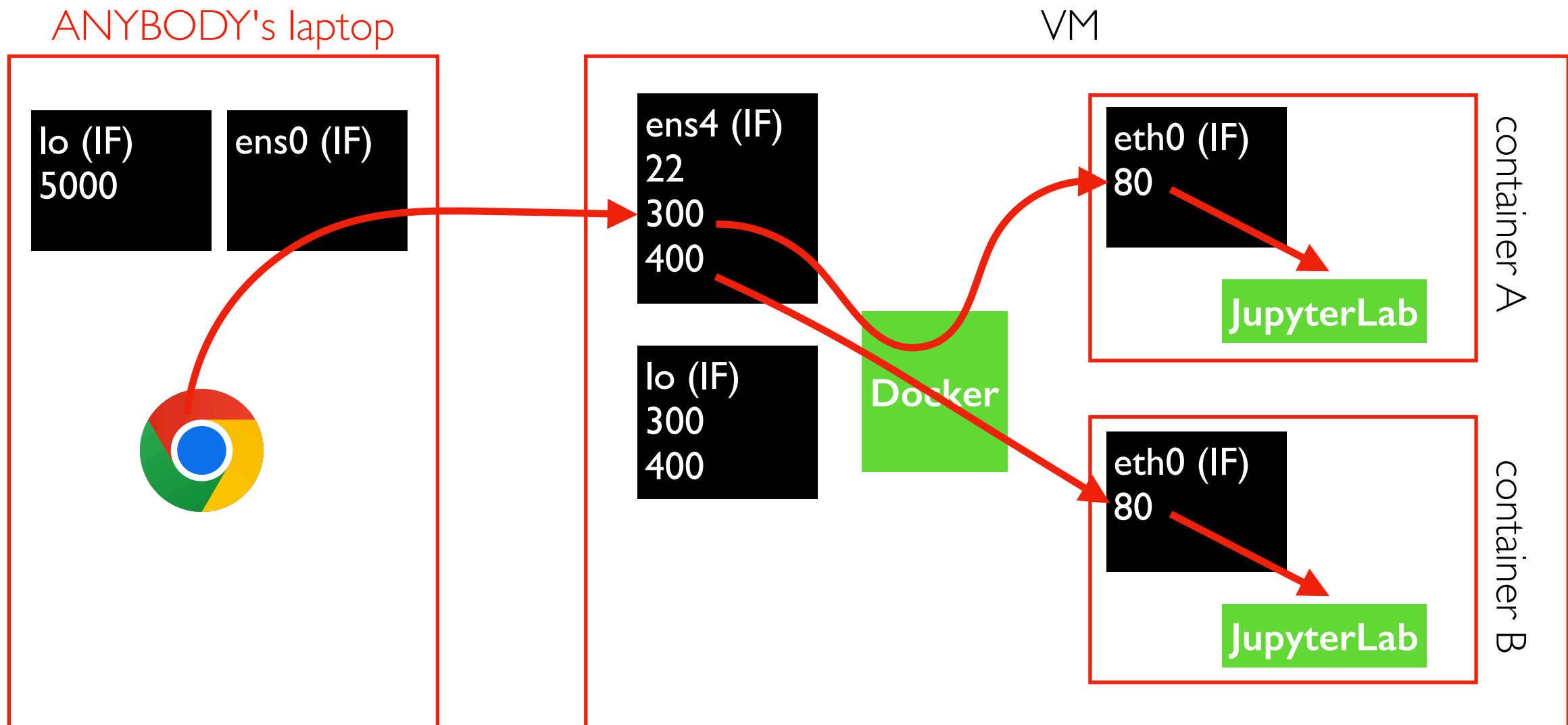


`ssh USER@VM -L localhost:5000:localhost:300`    `docker run -d -p 127.0.0.1:300:80 myimg`  
`docker run -d -p 127.0.0.1:400:80 myimg`

<http://localhost:5000/lab> (in browser)

yay! You can connect to JupyterLab  
inside a container running on your VM

# Interfaces (IF) and Ports



`docker run -d -p 300:80 myimg`



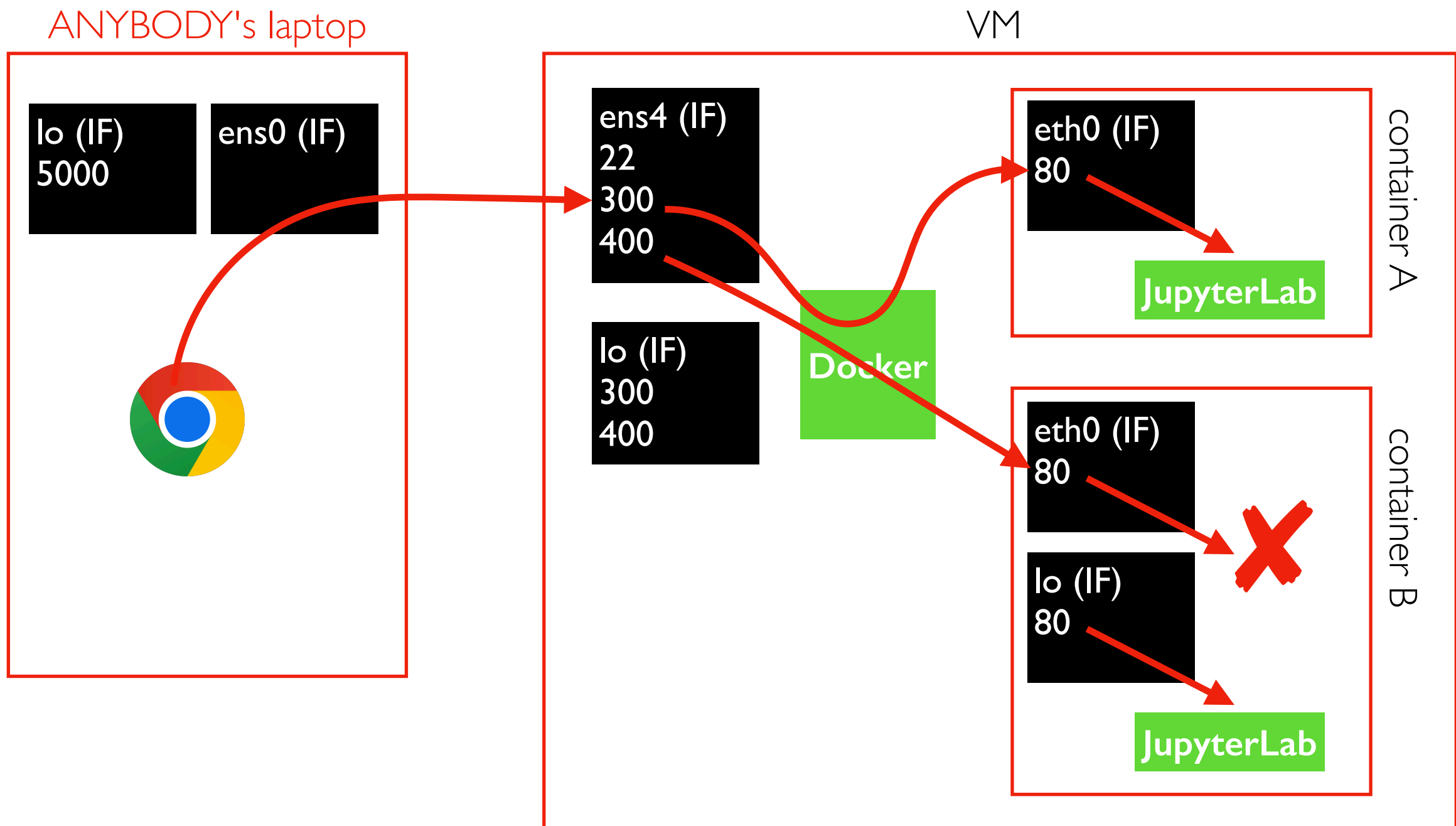
`docker run -d -p 0.0.0.0:300:80 myimg`

Careful, default is to listen on all NICs!

Other security options:

- firewall (block port 300)
- password (in JupyterLab)

# Interfaces (IF) and Ports



Port forwarding never goes to loopback inside container

- don't use localhost or 127.0.0.1 inside container!
- easiest: use 0.0.0.0 inside container (for all) to port-forwarded traffic

TopHat...

# Outline

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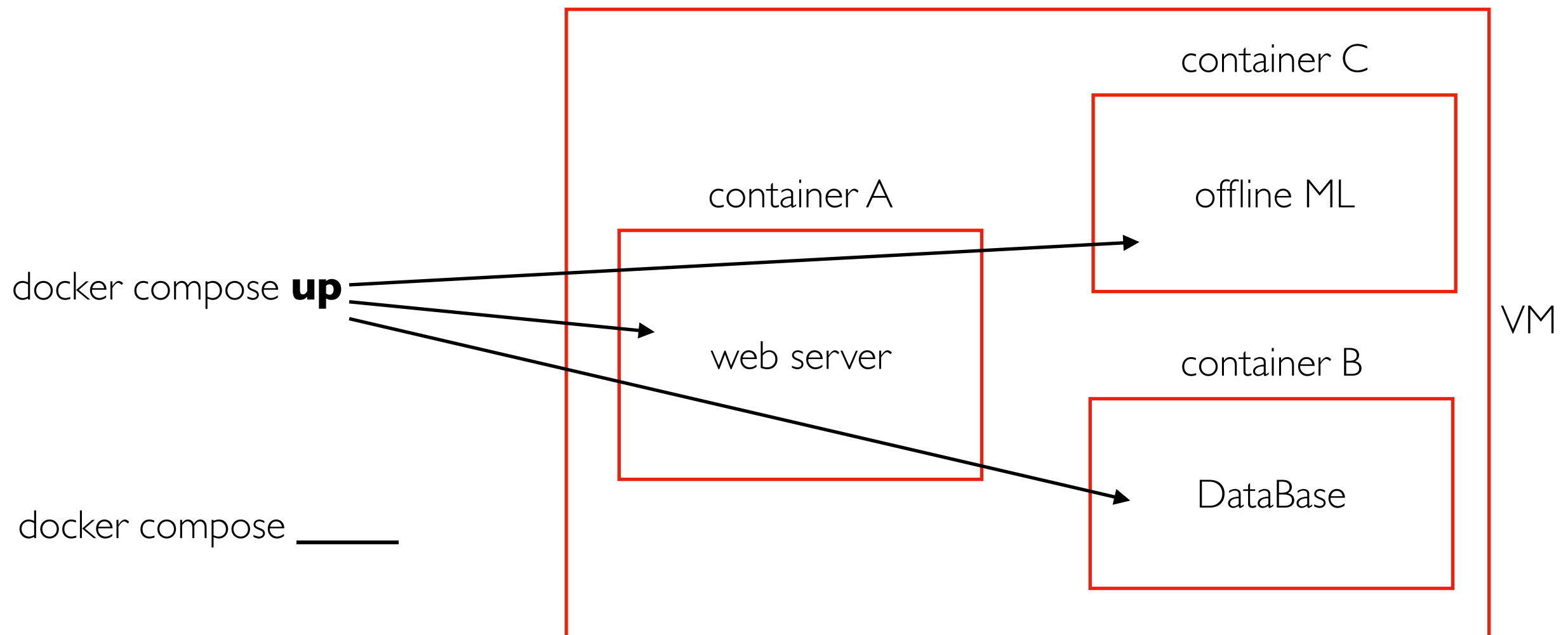
Docker Compose

# Container Orchestration

**Orchestration** lets you deploy many cooperating containers across a cluster of Docker workers.

**Kubernetes** is the most well known.

Docker **compose** is a simpler tool that lets you deploy cooperating containers to a single worker.



Demos...