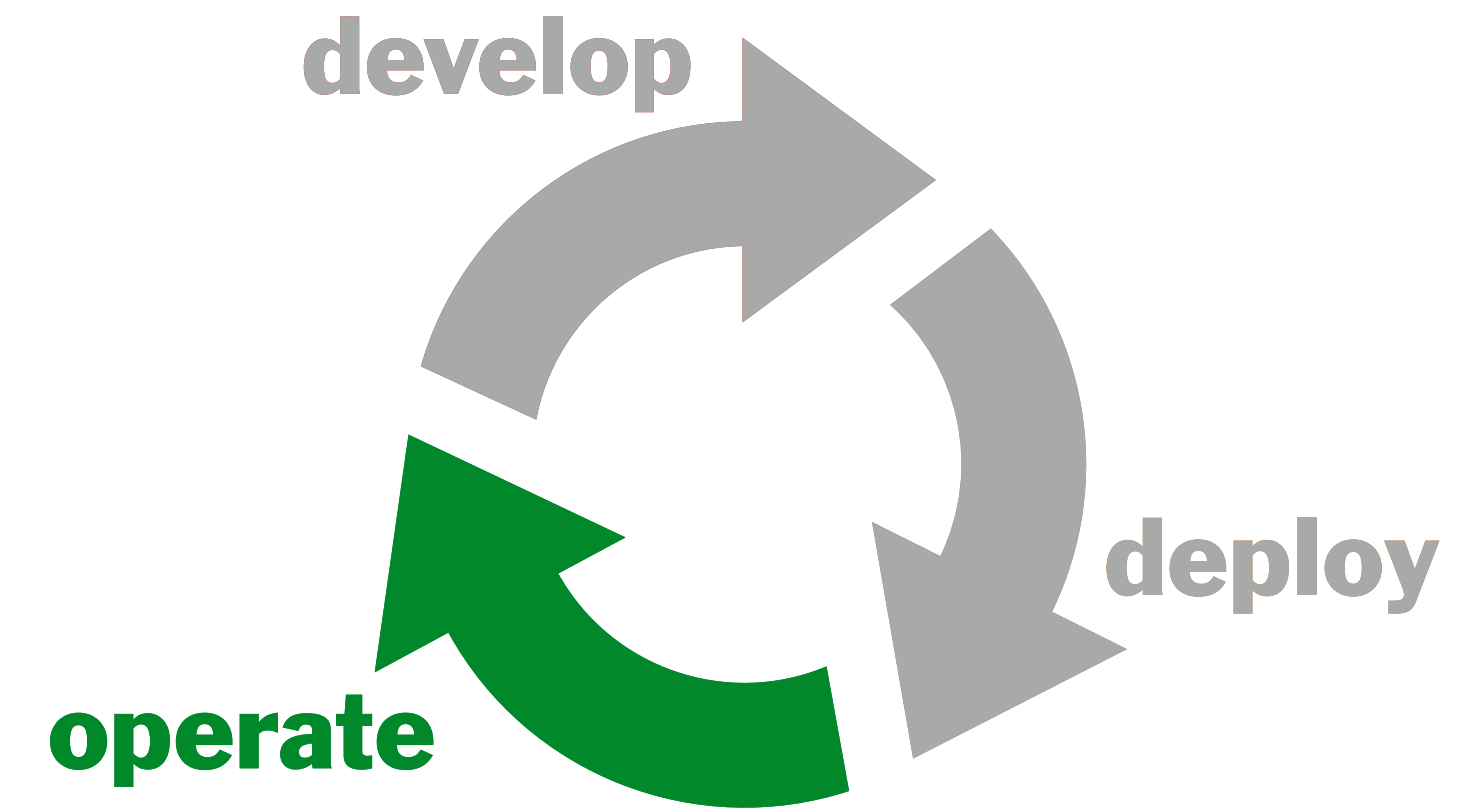


virtualization



cloud computing

learning objectives



- ◆ learn about the virtualization approach
- ◆ learn about the cloud computing approach
- ◆ learn how those two approaches relate

virtualization

in computing, **virtualization** refers to the act of **creating a virtual** (rather than actual) **version of something [...]***

*wikipedia.org

virtualization can exist at various levels in computing, e.g.,
hardware, applications, complete machines



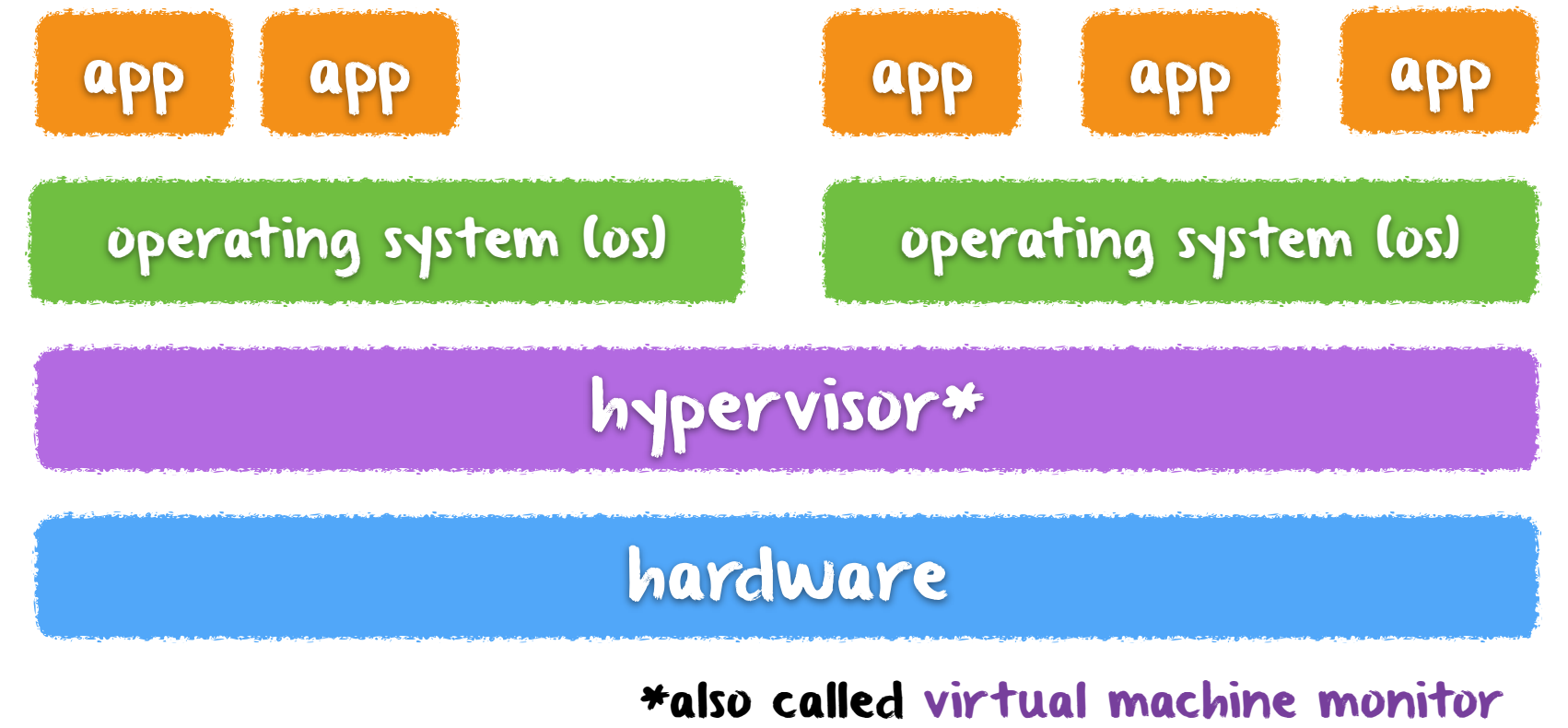
	reality (physical resources)	abstraction (virtual resources)
CPU	<i>n parallel cores</i>	<i>m concurrent threads, with $m \gg n$</i>
memory	<i>subset of 2^k addressable memory on a k bits machine, e.g., for $k = 64$, this is typically 8 to 32 gigabytes</i>	<i>full 2^k addressable memory for $k = 64$, this is 16 exabytes $\cong 16 \times 10^6$ terabytes $\cong 16 \times 10^9$ gigabytes</i>
	<i>in addition, each thread can access the full 2^k addressable memory as if it was for its exclusive use</i>	
storage	<i>hard disk drive (hdd), solid state drive (ssd), usb keys, etc...</i>	<i>file system offering persistency</i>
network	<i>i network interfaces, e.g., wifi, ethernet</i>	<i>j network connections, with $j \gg i$</i>

virtualization

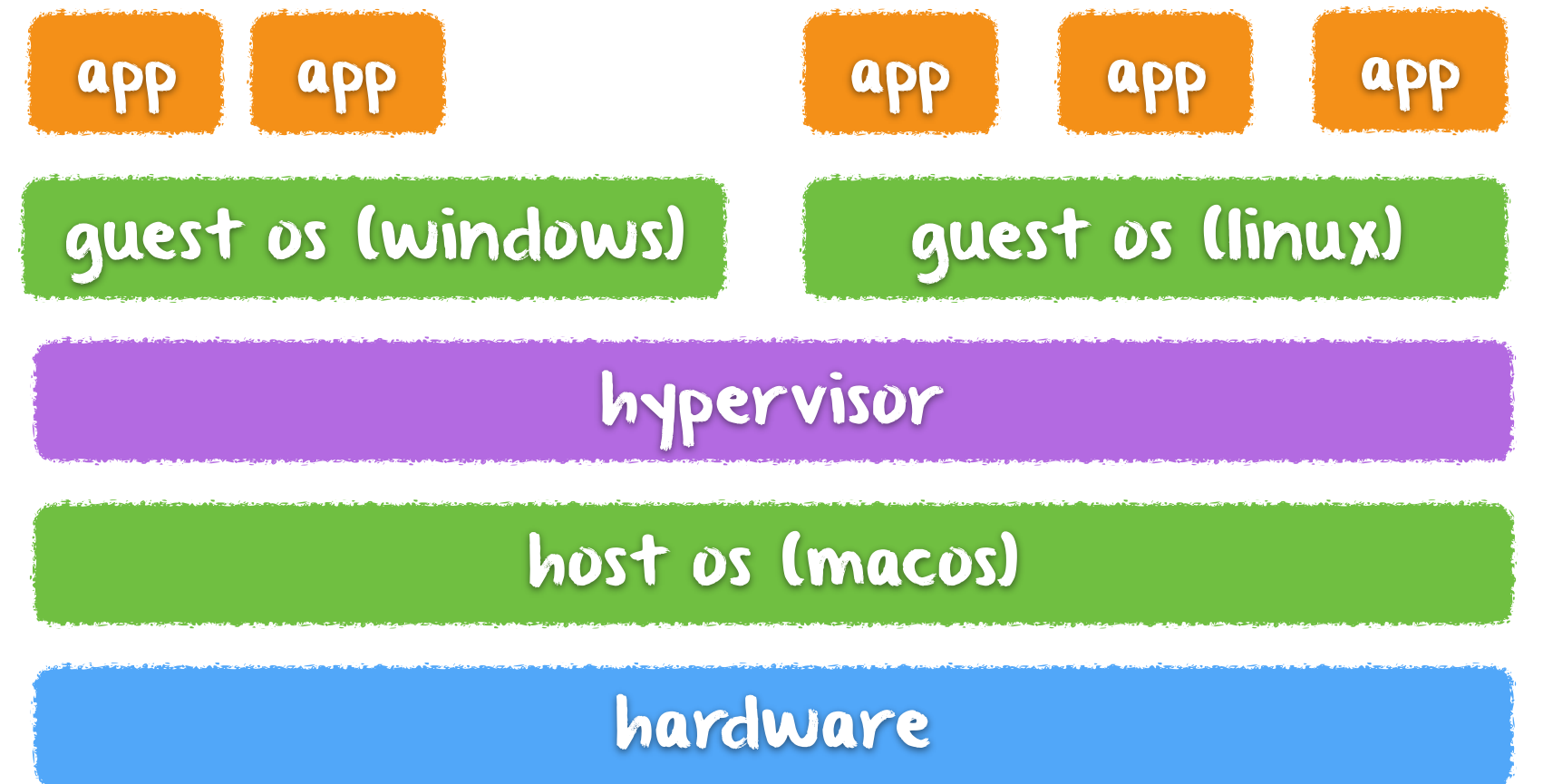
virtual machines



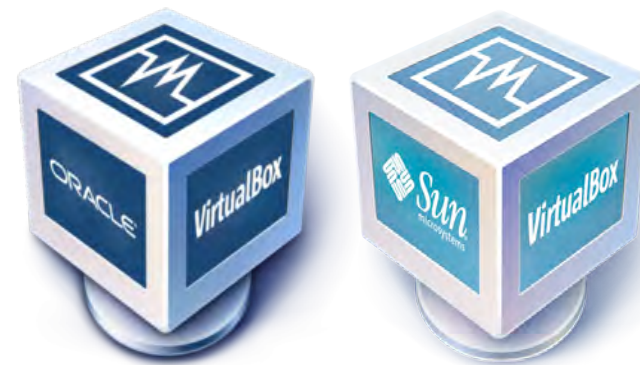
1960: first concept & implementation in the IBM S/360 operating system



since 1999: rebirth of this concept applying it to the Intel processor architecture



vmware®



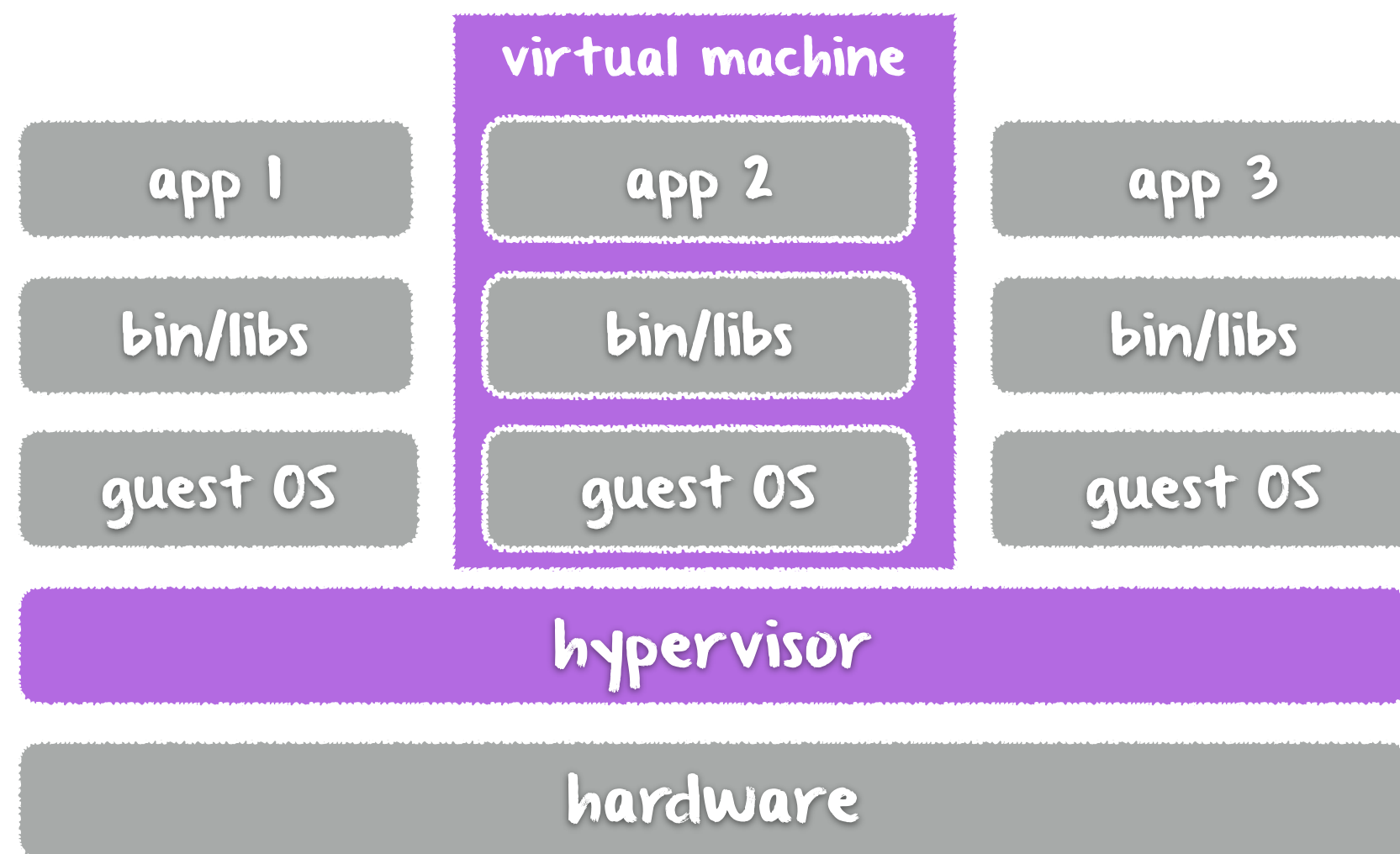
VirtualBox



Parallels®

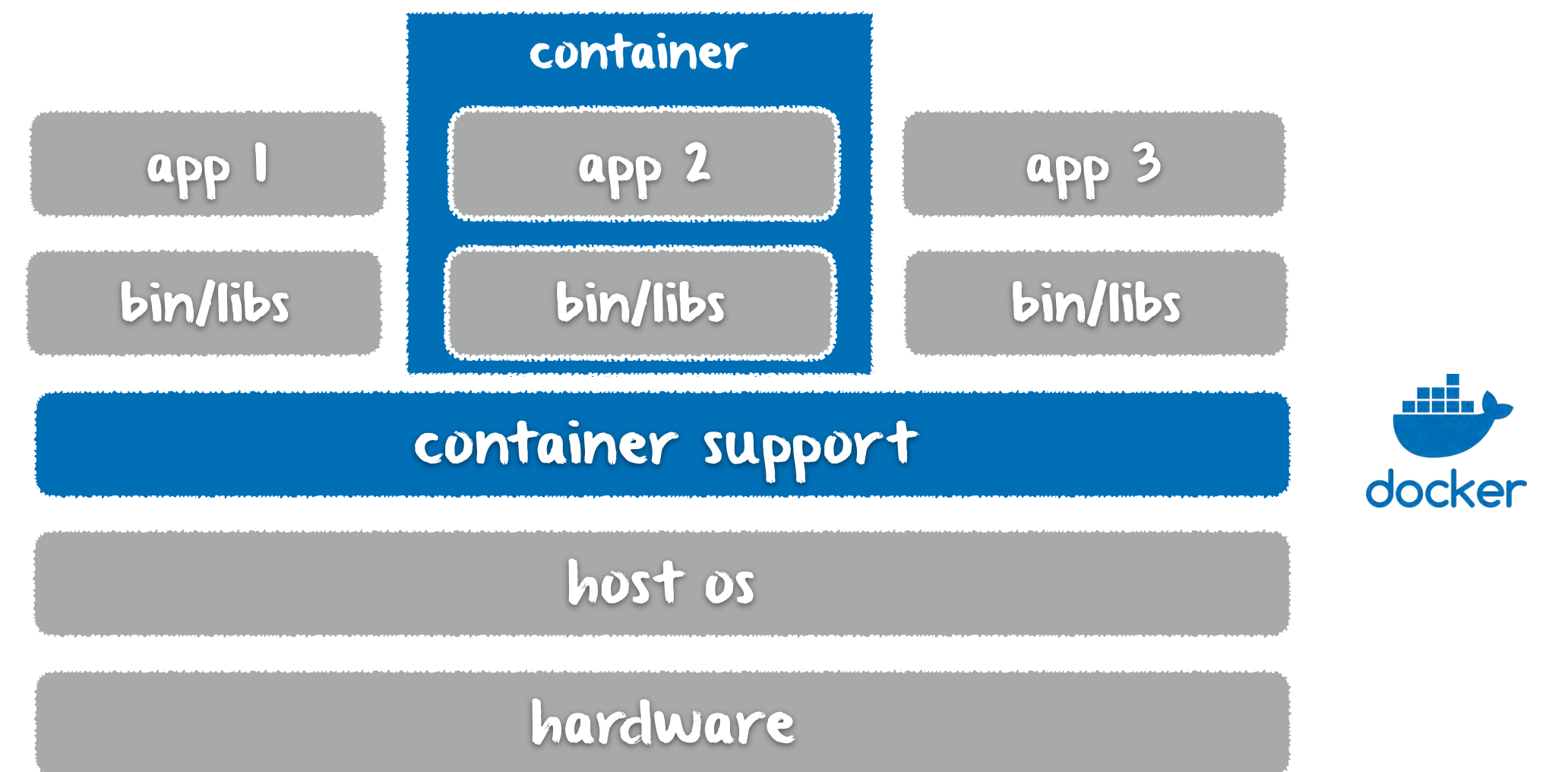
virtualization

virtual machines



- large memory footprint (tens of gigabytes)
- deployment is rather slow
- supports different operating systems on the same hardware

containerized applications



- small memory footprint (tens of megabytes)
- deployment is very quick
- supports only one operating system on the same hardware

app containerization is a lightweight variant of virtualization supporting faster deployment

it is particularly well suited for the fast deployment and redeployment of microservices

on-premises vs cloud computing

with **on-premises computing**, hardware and software resources are located **within the physical boundaries of an organization**, usually in its internally operated data center, and the **services they provide can be accessed via the organization's intranet**

with **cloud computing**, hardware and software resources are moved **outside the physical boundaries of an organization**, in a data center operated by a cloud provider, and the **services they provide must be accessed via the Internet**

cloud computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

The NIST Definition of Cloud Computing

Peter M. Mell, Timothy Grance

<https://dx.doi.org/10.6028/NIST.SP.800-145>

cloud computing

Infrastructure as a Service (IaaS)

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

The NIST Definition of Cloud Computing
Peter M. Mell, Timothy Grance
<https://dx.doi.org/10.6028/NIST.SP.800-145>

cloud computing

Platform as a Service (PaaS)

The capability provided to the consumer is to deploy onto the cloud infrastructure **consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.**

The NIST Definition of Cloud Computing

Peter M. Mell, Timothy Grance

<https://dx.doi.org/10.6028/NIST.SP.800-145>

cloud computing

Software as a Service (SaaS)

The capability provided to the consumer is to use **the provider's applications running on a cloud infrastructure**. The applications are accessible from various client devices through either a **thin client interface**, such as a web browser (e.g., web-based email), or a program interface.

The NIST Definition of Cloud Computing

Peter M. Mell, Timothy Grance

<https://dx.doi.org/10.6028/NIST.SP.800-145>

cloud computing

Infrastructure as a Service (IaaS)

- ◆ why buy when you can rent and scale?
- ◆ example: Amazon Web Services EC2

Platform as a Service (PaaS)

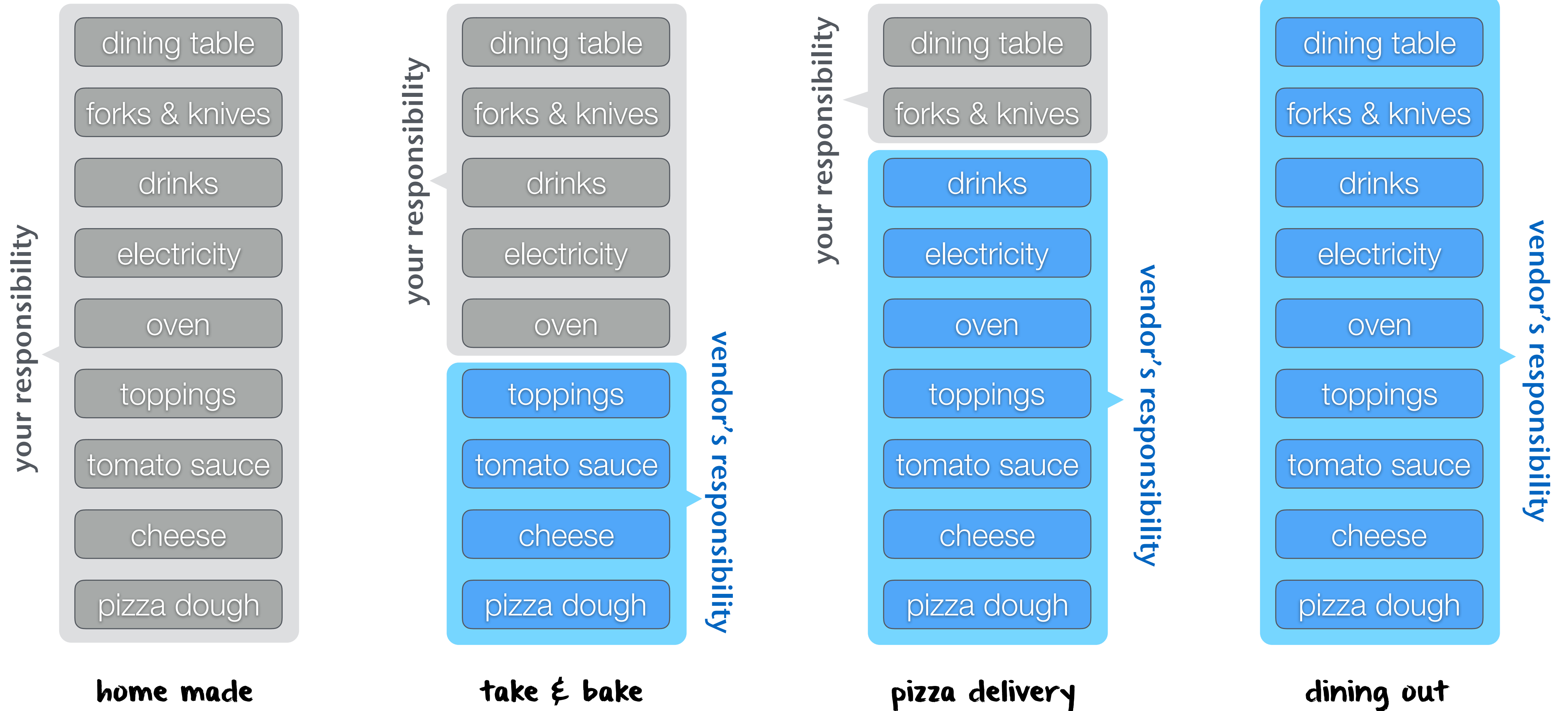
- ◆ give me a nice api with a solid implementation!
- ◆ example: Amazon Web Services Lambda

Software as a Service (SaaS)

- ◆ run it for me and make it accessible anywhere!
- ◆ example: google docc

cloud computing

from pizza...



home made

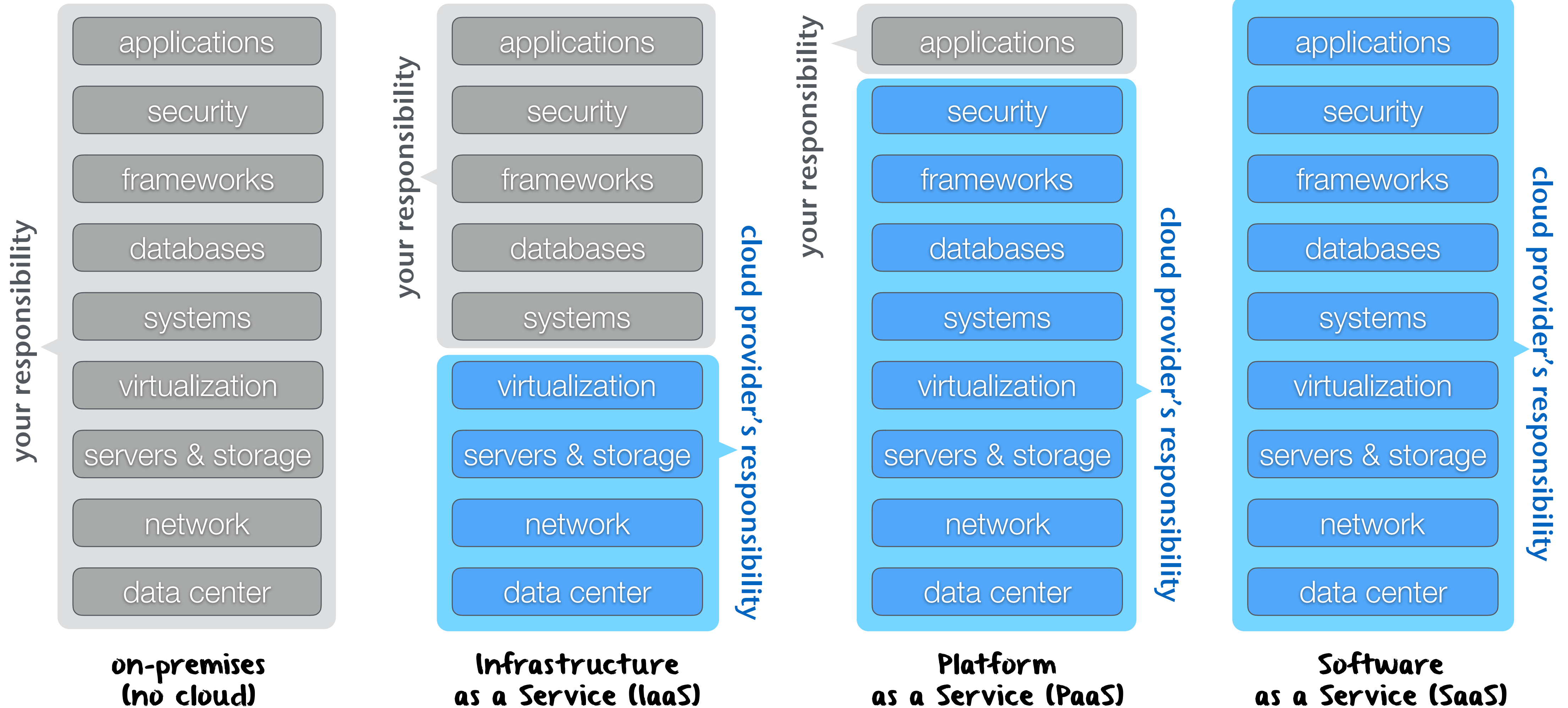
take & bake

pizza delivery

dining out

cloud computing

...to the cloud!



cloud computing

when to go for the cloud?

1'000 servers

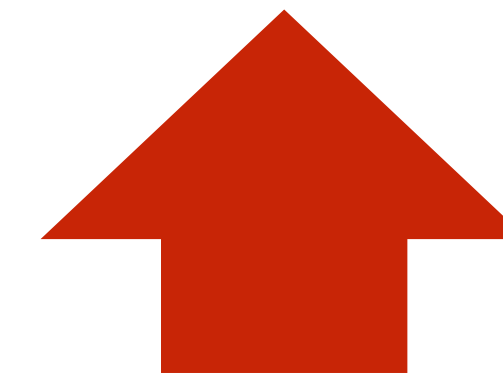
100'000 servers



startups



NETFLIX



facebook

the **number** of servers is **not the only criterion** in the decision to **go for the cloud** or not

the **security and privacy** of your data is also a key factor

cloud computing



and counting...