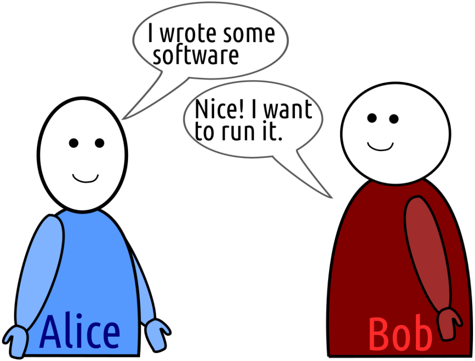
Alice, Bob, and the problem of distributing software – a DevOps tale

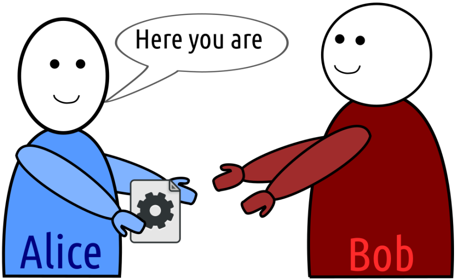
The core problem

- *Alice made a software tool*
- *Bob wants to run Alice's software*
- How can Alice make her software available to Bob?
- How can Bob run Alice's software?



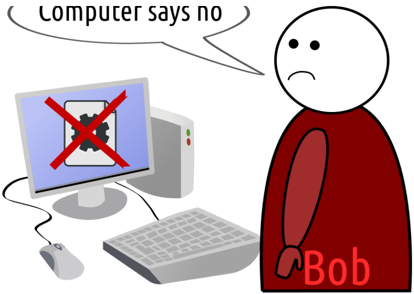
Solving the problem?

- Alice gives Bob an executable
- Bob runs the executable



The real problems begin... (1/2)

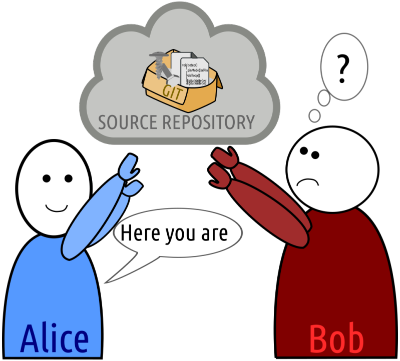
Problem solved?



- Is Alice's executable suited for Bob's OS and architecture?
  - No? Alice must provide multiple executables for different systems
  - No? Bob must use *virtualisation* to emulate another OS/architecture.
  - Not compiled but interpreted? Bob must have the necessary interpreter (e.g. Python, JS, Java)

Back to the origin: Open Source

- Give Bob the source code and let him build the program himself?
- Ideally via a source version-controlled repository (e.g. GitHub, GitLab, BitBucket)
- Requires a higher level of technical expertise from Bob



The real problems continue: Dependency Hell (2/2)

- Does Alice's program make use of any other software (libraries) Bob also needs?
  - Alice must either provide or make explicit all her dependencies
  - Bob must ensure he has all the necessary dependencies before the program can run
- Alice's program may want to interact with other applications on the system?
  - Bob must ensure they're installed and set up properly
  - Related: Static linking vs Dynamic linking
- Recursive problem, conflicting requirements: **Dependency Hell**

Traditional solution: packaging and distributions

- Distributions host packages for common software in a *package repository*
- Packages in a distribution are carefully tuned to interoperate with one-another (ABI/API compatibility etc)
- A package manager handles packages and all their dependencies (apt, yum, apk, pacman, brew)
- Alice can now build a package (deb, rpm, apk) and add it to a repository from which Bob can install it.

Problem solved?

- No, there are many different distributions -> many package repositories
- Maintaining packages takes time and effort (for Alice)
- Packages have to be kept up to date (for both Bob and Alice)

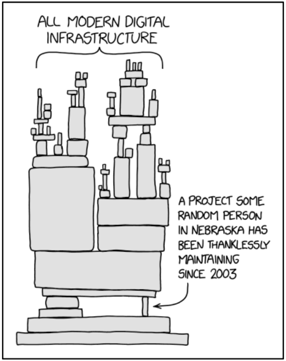
Language ecosystems

- Language-ecosystems provide their own package repositories:
  - *Python* - Python Package Index - `pip`
  - *NodeJS* - `npm`
  - *Rust* - crates.io - `cargo`
  - *Java* - Maven Central - `maven`
  - *perl* - CPAN
  - *R* - CRAN
  - Ruby - Rubygems - `gem`
- If Alice's software fits into one of the ecosystems well, she should provide a package there

Software complexity: layers upon layers

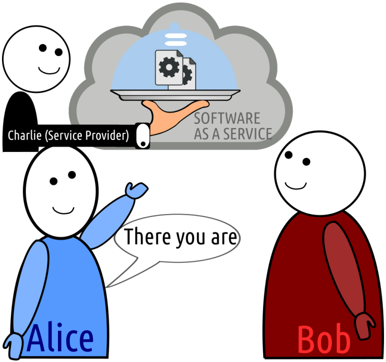
Problem solved?

- No, Alice's software application may be an integration of an interconnected set of diverse software components:
  - Various languages: doesn't fit a single language ecosystem
  - Various audiences: doesn't fit a single distribution
- Though maybe captured in multiple more traditional packages, **configuring** the integration is often not trivial



Software-as-a-Service (SaaS)

- Instead of giving Bob the actual program, Alice makes her software available **as a service**.
- Bob can simply access it as a **web application** through his browser (or programatically interact with it as a **web service**)
- Alice now gives her program to Charlie instead of Bob, to **deploy** on a server, Bob accesses Charlie's server.

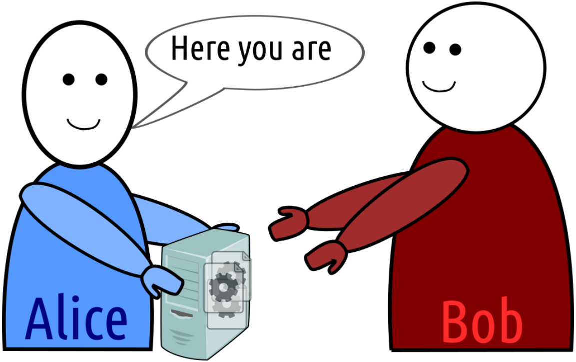


Problem solved?

- The burden shifts from Alice and Bob to Alice and Charlie (who has more technical expertise)
- **Service-as-a-Software Substitute**: having access to a service is a convenience but is **NOT** a substitute for having the actual software.
  - Privacy, data ownership and trust concerns
  - Low-level interoperability hindered: Increased latency, requires network connection
  - Business model vs technical solution
  - Can be a loophole to not provide the source code anymore (GPL vs AGPL)
  - Not suited for everybody

Virtualisation

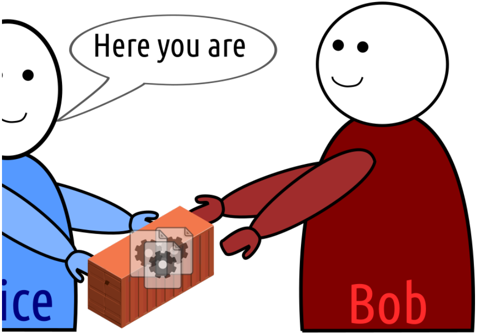
- Bob: *"your program doesn't run"*
- Alice: *"But it works on my machine"*
- **Solution:** Alice just gives Bob a copy of her machine and Bob's machine *emulates* Alice's machine: a **virtual machine**



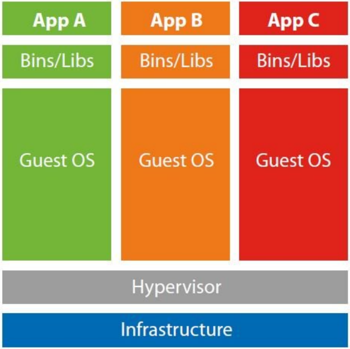
- Takes us back to scenario 1, *"Alice gives Bob an executable"*, but in the broadest possible sense of executable.
- Bob now only requires a **hypervisor** to run the VM.
- **Advantages**: Bridges OS differences, isolation from host (security)
- **Problem solved?** No
  - Performance penalty
  - Duplication
  - Resource overhead
  - Isolation from host (integration)

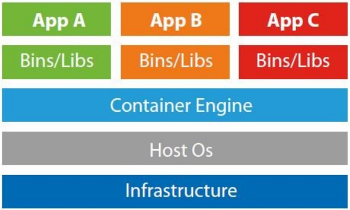
Containerisation

- Alice again gives Bob a copy of her machine: a **container**.



- Share the (Linux) kernel; isolate the rest, no virtualisation needed
- Takes advantage of facilities in the (Linux) kernel
- Significantly reduces resource overhead & performance penalty
- *Caveat:* container engines may resort to virtualisation anyway on non-Linux platforms (e.g. Docker on Windows or macOS)





Container platforms and paradigms (1/3)

Docker:

- Application containers, lightweight containers serving ideally single applications
- Non-persistant storage
- Layered images
- Containers are stateless (spun upon anew), all persistant data on externally mounted volumes
- Docker Hub as Container Registry (image store)
- Great for applications containers, deployment of services in cloud infrastructure
- Most known and widely used
- Less suitable for High Performance Clusters (security)

Container platforms and paradigms (2/3)

LXC:

- System containers: acts like a lightweight VM, more traditional environment
- Single-layer image
- File-system neutral
- Persistant storage (typically)
- Fat containers that may serve multiple applications, have a full *init system*.

Container platforms and paradigms (3/3)

Singularity:

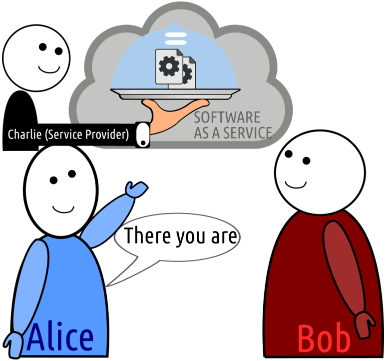
- Specifically designed for High Performance Clusters and multi-user environments
- Can use docker images
- No elevated permissions required (security)

Provisioning a container (or VM)

- *"Alice gives Bob a copy of her machine"*
- Alice builds a (container/VM) image
- using an automated recipe for provisioning (e.g. Dockerfile, shell script, Ansible)
- Alice publishes the container image in a registry
- Bob obtains the container image from the registry

Container Orchestration

- Alice decided on Software-as-a-Service
- Alice gives Charlie a copy of her machine: a **container**, to offer as a service for Bob and others.



Problem solved?

- Alice's service may comprise multiple containers that need to interact.
  - L'histoire se répète?
- Alice's service may be so popular that running it on a single system is not sufficient (scalability)
- What if Alice's program fails and the service goes down?
- **Distributed Computing**: containers can easily be deployed on multiple systems
  - Schedule when a container runs and where it runs (load balancing etc)
  - Spin up multiple containers at once (e.g. docker compose)
  - Spin them up over multiple machines (e.g. docker swarm, kubernetes)
  - Restart a container when it fails (kubernetes)
  - Abstract over the hardware (kubernetes)

Recap

- Distribution
- Packaging
- Software as a Service
- Deployment
- Virtualisation
- Containerisation
- Container Orchestration

Recommendations for the CLARIAH infrastructure

No single solutions fits all, be aware of all the different layers and audiencies.

For all individual software components:

- Try to make software components minimal components that are reusable
- Publish the source code in **public** Version Controlled Source Repositories (e.g. GitHub)
- Include software metadata with the source code (as codemeta or language-specific)
  - All direct dependencies must be made explicit
- Release software versions periodically when deemed stable
- Package and distribute all the software through proper channels:
  - Language-ecosystem-specific repositories (PyPi, CRAN, Maven etc)
  - or for specific distributions if appropriate

For software services (SaaS):

(Offering a service is perfectly valid, and one of the aims of CLARIAH, but is **not** a substitute for offering the actual software that the user can run himself/herself)!

For software services (SaaS):

- Software services should be delivered to service providers in **containers**:
  - Docker is the most industry-standard solution:
    - Software **developers** should provide a Dockerfile (in public version-controlled source repository) allowing anyone to build a container/ multiple containers to deliver the service
    - Application containers (hosting a single application) should be preferred
    - CLARIAH should set up a container registry for use by all participants
    - All service endpoints that a container exposes should be clearly documented
  - When multiple interacting containers are delivered, an initial Compose file or Kubernetes configuration should be provided by the software **developers** to orchestrate them.
    - These should be stored in code in version control (may be private).
  - CLARIAH should draft clear infrastructure requirements: the NDE example is excellent to copy and follow, which is in turn partially based on the Twelve-Factors.

References

- NDE Infrastructure requirements: https://github.com/netwerk-digitaal-erfgoed/requirements-infrastructure
- Twelve Factors: https://12factor.net/
- Clipart: openclippart.org (heavily modified by me without any real artistic talent)
- XKCD (comics)