Pathfinding into the clouds

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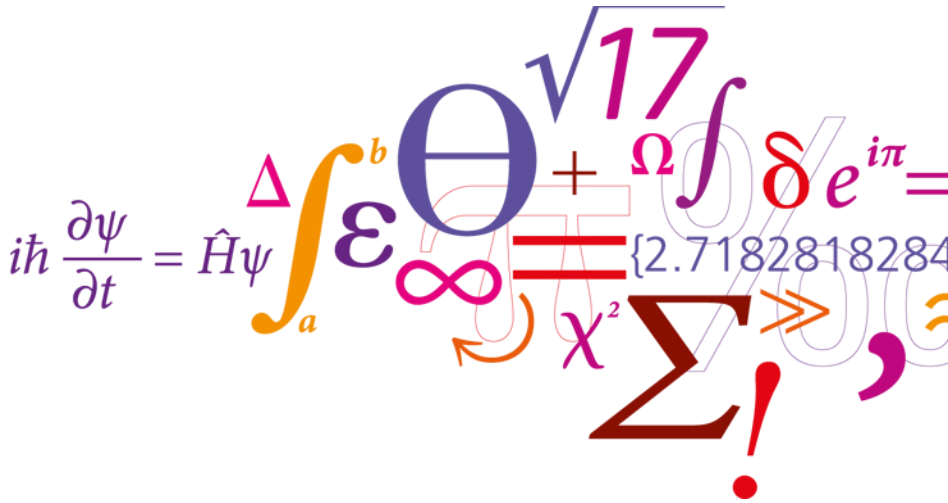
See the Wiki page:
https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting



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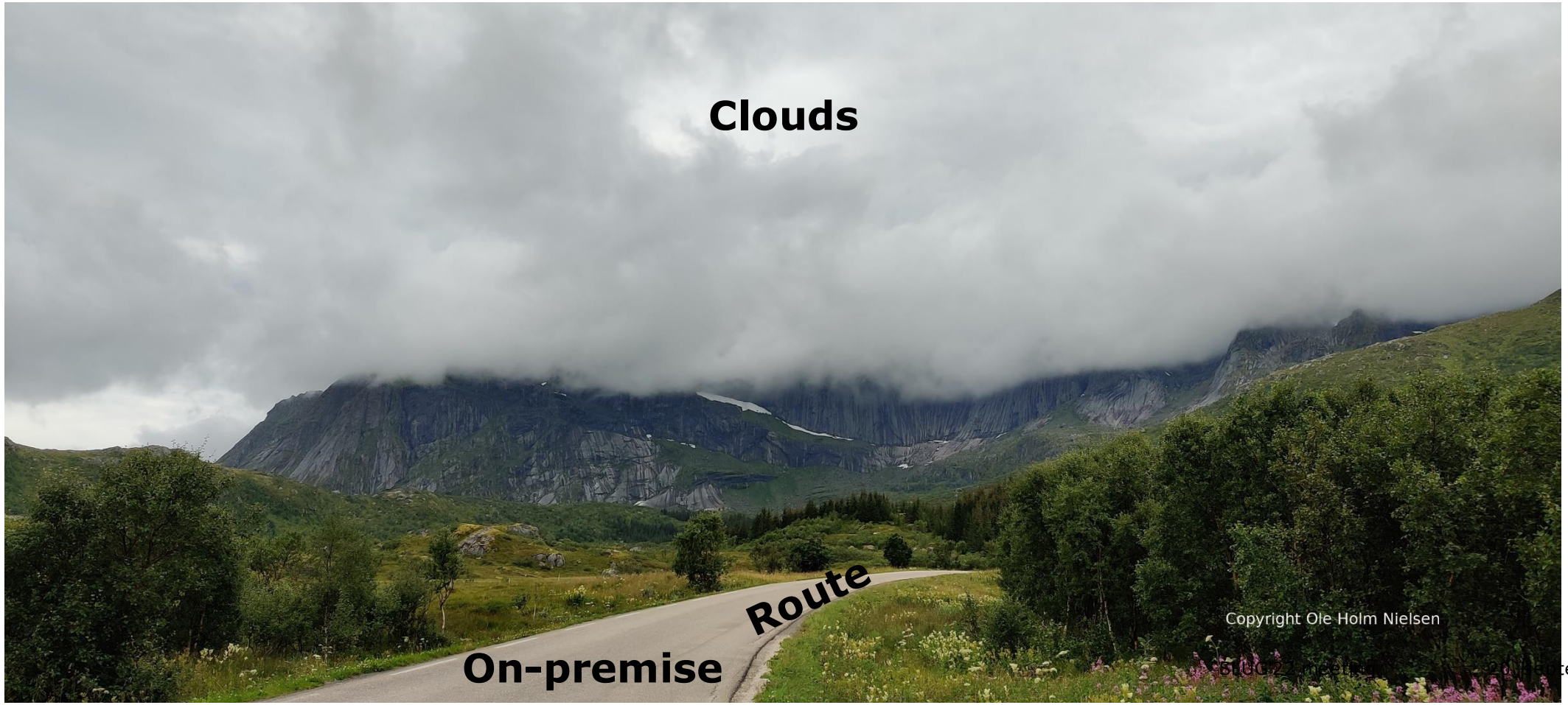
Pathfinding: Plotting by a computer application the shortest route between two points (Wikipedia)



Scaling an on-premise cluster into the clouds

Use cases:

- Extend cluster on-demand with compute nodes in the cloud.
- Access to CPU types other than what's in your on-premise cluster.
- Access to GPUs and other accelerators in stead of buying them.

Outline of talk:

1. This work is based on the **Azure** cloud service.
2. Open an account at the cloud service provider.
3. Create one or more cloud Virtual Machines (**VM**) and a Virtual Network (**Vnet**).
4. Create a **VPN IPsec** tunnel between your on-premise subnet and the cloud **Vnet**.
5. Write a script to power up/down VMs.
6. Define storage space in the cloud for application software and user data.

Open an account at a cloud service provider

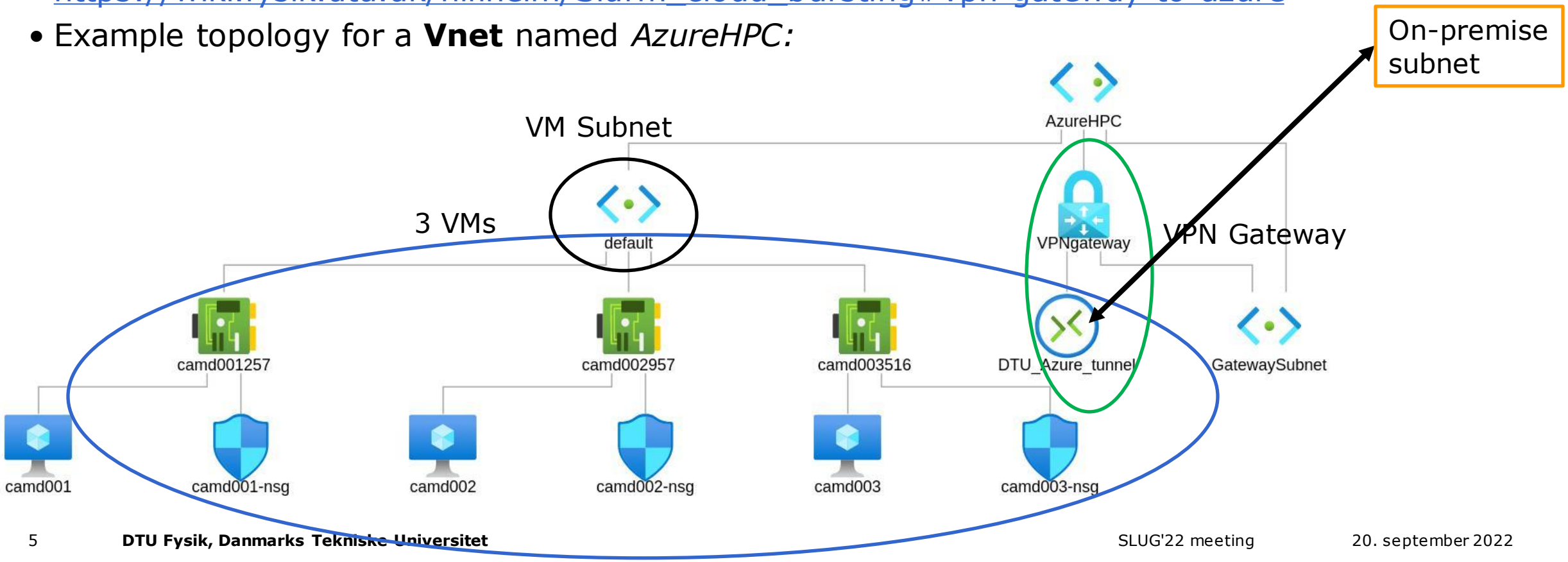
- The present work is based on the **Azure cloud service** with guidance from Azure experts in Denmark.

- Many universities and other organizations already have a central IT **Azure Subscription**. We asked our central IT to create an Azure account for us.

- Details are at https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#resources-for-slurm-on-microsoft-azure

Create cloud Virtual Network and Machines

- Create an Azure **Virtual Network** (**Vnet**)
  https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#virtual-network-in-azure
- Create a **VPN Gateway**
  https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#vpn-gateway-to-azure
- Example topology for a **Vnet** named *AzureHPC:*



Create a Virtual Machine

- Create a VM based upon some pre-existing minimal VM image: https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#create-resources-and-machines-in-azure-home
- **AlmaLinux** images are freely available in **Azure**.
- **RockyLinux** images are only available for pay in **Azure**.
- You must save the VM's *SSH public key file* and use it later to login via the *VPN tunnel*.
- Remember to shut down VMs when they are not in use!

On-premise IPsec VPN Gateway

- This is the least documented part of the cloud bursting adventure!
- Create a **Site-to-Site IPSec VPN connection** in Azure: https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#configure-vpn-gateways
- Azure provides a list of supported *compatible hardware router devices* (Cisco, Juniper, etc.) with links to vendors' configuration guides.
- **Problem**: What to do if you don't have the money to buy an expensive router, and/or the time to become an expert in the router's OS configuration???

Solution: Build your own IPsec tunnel

Beware of strange problems lurking in tunnels

Libreswan comes to the rescue

- **Libreswan** is a free software implementation of the most widely supported and standardized VPN protocol using *IPsec* and the *Internet Key Exchange* (IKE).
- Use any Linux server with 2 NICs as the on-premise VPN gateway to the cloud service. One NIC faces the public Internet, the other NIC is in your cluster subnet.
- *RHEL 8* (and clones such as *RockyLinux* and *AlmaLinux*) comes with *Libreswan* v4.4.
- There are numerous web-pages with instructions for setting up a site-to-site VPN tunnel. We have tried dozens of these methods, but none have worked on an EL8 server ☹
- Azure does not *support* Libreswan for VPN tunnels ☹
  But it works nevertheless!

Libreswan setup that *actually* works

- *Libreswan* setup details (firewall, IPsec, routing, etc.) are in: https://wiki.fysik.dtu.dk/it/Libreswan_IPsec_VPN

- Example IPsec configuration file `/etc/ipsec.d/azure.conf`:

```
conn azure                # Connection name
left=123.45.67.89         # Local VPN gateway public address
leftsubnet=10.2.0.0/16    # Local subnet
leftsourceip=10.2.0.1     # Local VPN gateway on the local private subnet
right=20.21.22.23         # Azure VPN gateway public address
rightsubnet=10.0.0.0/16 # Azure subnet
authby=secret             # Use shared secret with Azure
auto=start                # Start Ipsec at reboot
dpdaction=restart         # Restart if peer has died
dpddelay=30               # Dead peer delay
dpdtimeout=120            # Dead peer timeout
ike=aes256-sha1;modp1024 # IKE encryption/authentication algorithm
ikelifetime=3600s         # IKE renegotiation
pfs=yes                   # Perfect Forward Secrecy
esp=aes128-sha1           # Child SA negotiation algorithms
salifetime=3600s          # Expiry of a connection
```

Integrating cloud VM nodes with your on-premise cluster

- At this point your on-premise cluster subnet servers can communicate directly with TCP/IP via the *Libreswan IPsec* router (or a hardware router).
- Now you can SSH to a VM to configure the OS and install any necessary applications, as you would do with any on-premise node.
- We use Ansible for node configuration: https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#ansible-with-azure
- Authentication: Configure users in the VMs as you normally do in your cluster (for example, add users to `/etc/passwd`).
- Your custom VM can now be cloned to create many identically configured VMs: https://docs.microsoft.com/en-us/azure/virtual-machines/capture-image-portal

Configure Slurm to power up and down VMs

- Slurm Power Saving guide https://slurm.schedmd.com/power_save.html

- Configure Slurm powering scripts:
  https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#slurm-configuration-for-cloud-nodes

- Slurm powering scripts for Azure:
  https://github.com/OleHolmNielsen/Slurm_tools/tree/master/cloud
  The scripts can also be used without Slurm.

Azure shared NFSv3 Storage Blobs

- In February 2022 Azure started offering NFSv3 Storage Blobs: https://docs.microsoft.com/en-us/azure/storage/blobs/network-file-system-protocol-support

- This support provides Linux file system compatibility at object storage scale and prices and enables Linux clients to mount a container in Blob storage from an Azure *Virtual Machine* (VM) or **a computer on-premises**.

- Setting up an Azure *Storage Account*: https://wiki.fysik.dtu.dk/niflheim/Slurm_cloud_bursting#azure-storage-accounts

- Now you can NFS-mount the Azure Blob storage container's IP-address/DNS-name.
  This works inside your VMs as well as
  in your on-premise servers (via the VPN tunnel)!
  We use the NFS auto-mounter with Azure storage.

- You may create user home directories in the Azure storage.

Test Slurm with cloud nodes

- Read the Slurm Cloud Scheduling Guide:
  https://slurm.schedmd.com/elastic_computing.html

- Add cloud nodes to Slurm as described in a previous slide.

- Submit batch jobs to run on the cloud nodes.
  Cloud nodes will be powered up and down on-demand.