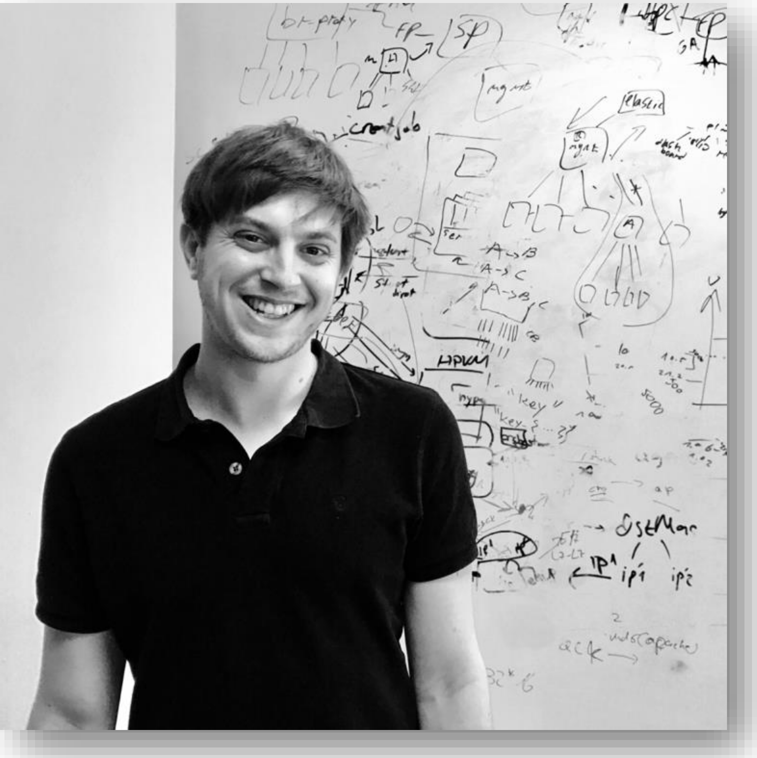
ESCALATING INSIDER THREATS USING VMWARE'S API

Ofri Ziv, GuardiCore

Who am I?

- VP Research at GuardiCore
  - Head of GuardiCore Labs
  - Security research
  - Development of data analysis algorithms
- Msc in Computer Science
- Over 10 years of cyber security research experience
- Prior work: [Bondnet](), [Infection Monkey]()

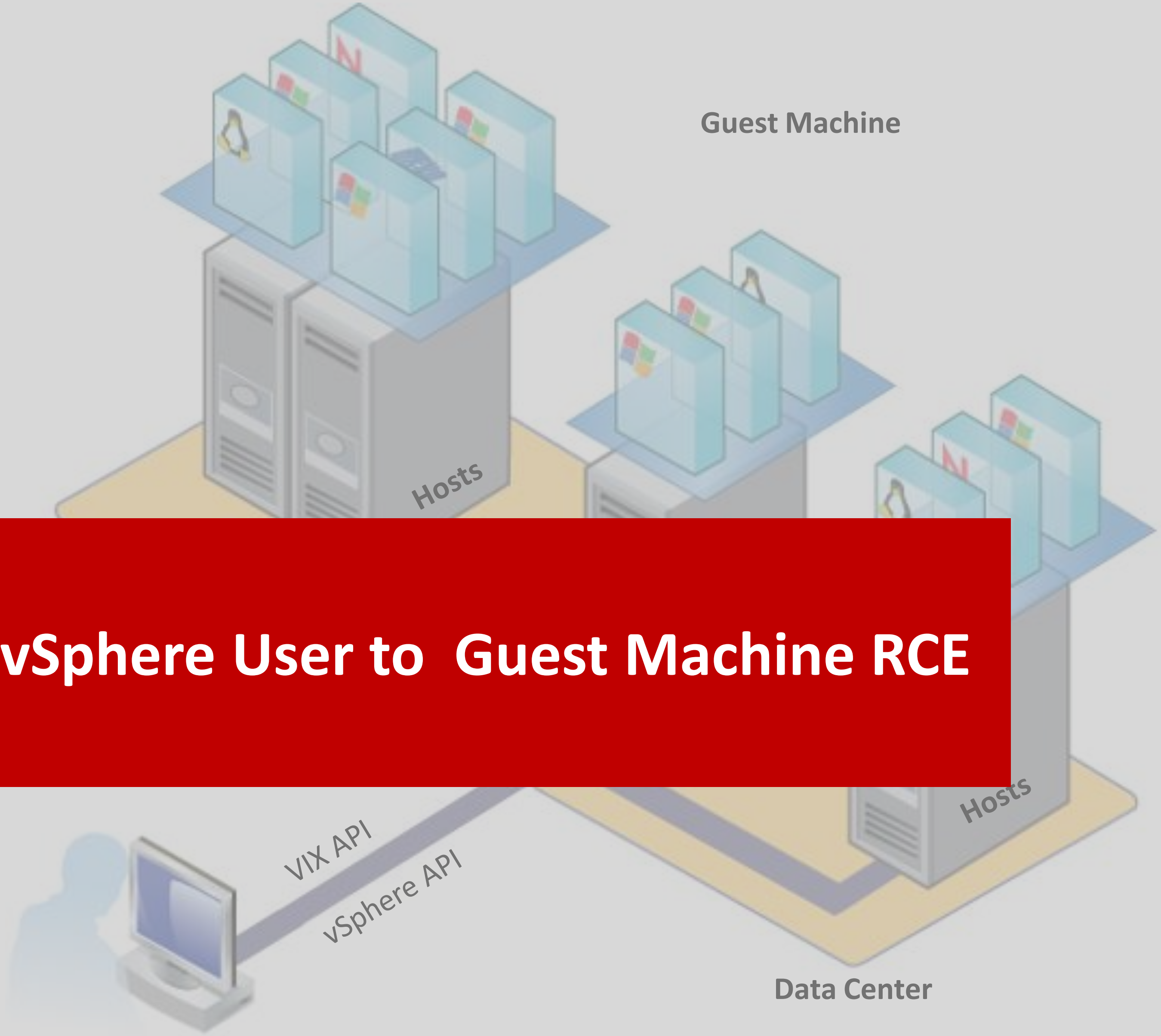


GuardiCore

- Cloud & Data Center security company
- [www.guardicore.com]()

Agenda

- Overview of host-guest isolation model
- Use case (SOD)
- Attack Flow
- Demo
- Who is vulnerable?
- Mitigation



From vSphere User to Guest Machine RCE

Host-Guest Isolation

- Any virtualized data center needs to provide isolation between host and guest machines
- Separation of Duties
- Required by regulations

PCI DSS COMPLIANT

HIPAA
Health Insurance Portability
& Accountability Act

Host-Guest Isolation

> *Guest virtual machines should be **isolated** from the host and from other guests running on the same host. **Interaction** between the host and guests [...] should occur only through channels with **well-understood and documented security properties***
>
> *- **VMware***

https://www.vmware.com/support/developer/vix-api/vix115_reference/security.html

Isolation – How To

> *To use the VIX API for guest operation, applications* ***must authenticate with two distinct security domains:***
>
> 1. *The client must first* ***authenticate with the vSphere host.***
> 2. *The client must then supply a* ***valid credential for the guest operating system*** *on any virtual machine where it wants to perform guest operations*
>
> ***- VMware***

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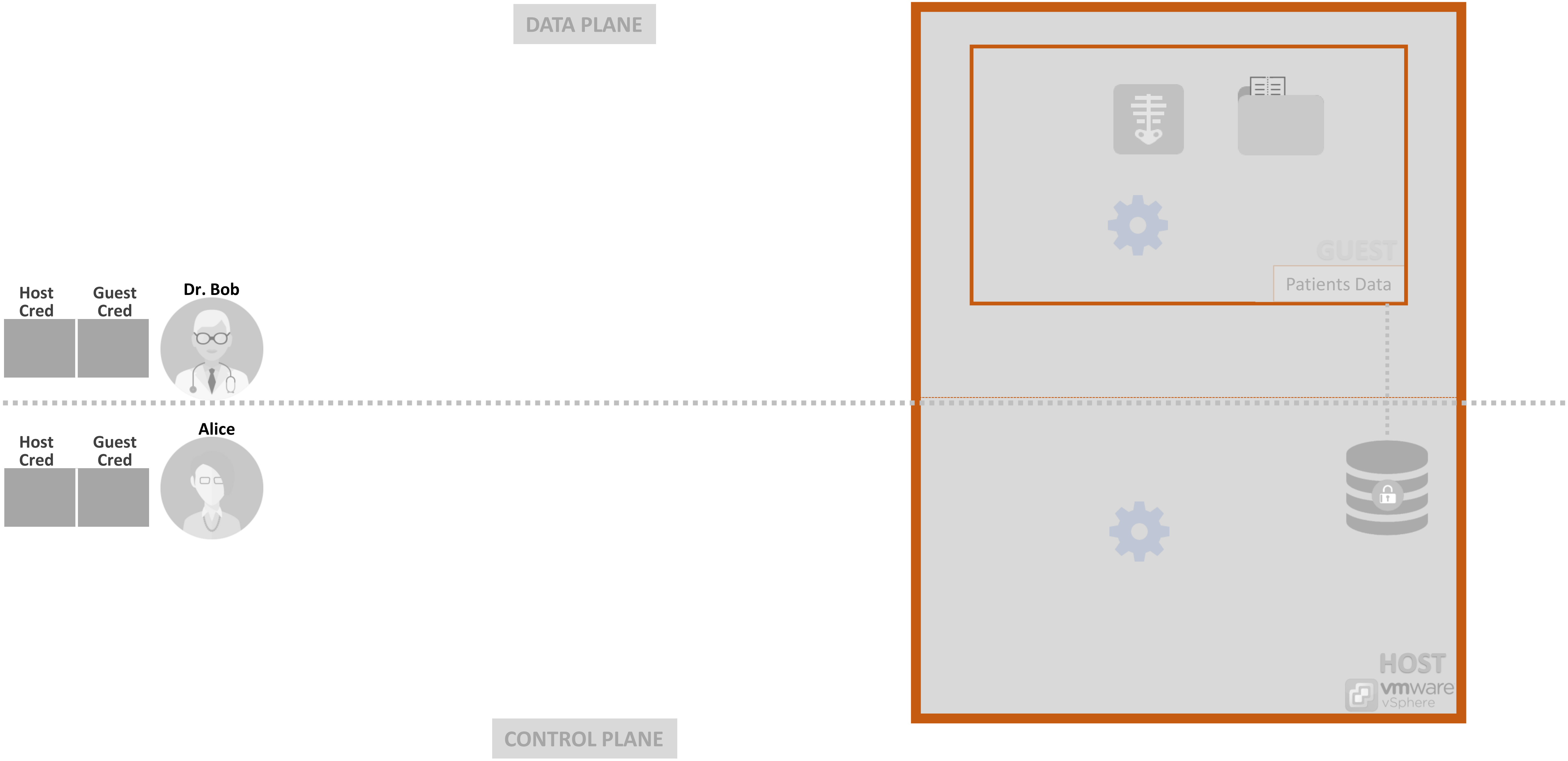
A built-in functionality in vSphere breaks the host-guest security model



DATA PLANE

Host Cred

Guest Cred

Dr. Bob

Host Cred

Guest Cred

Alice

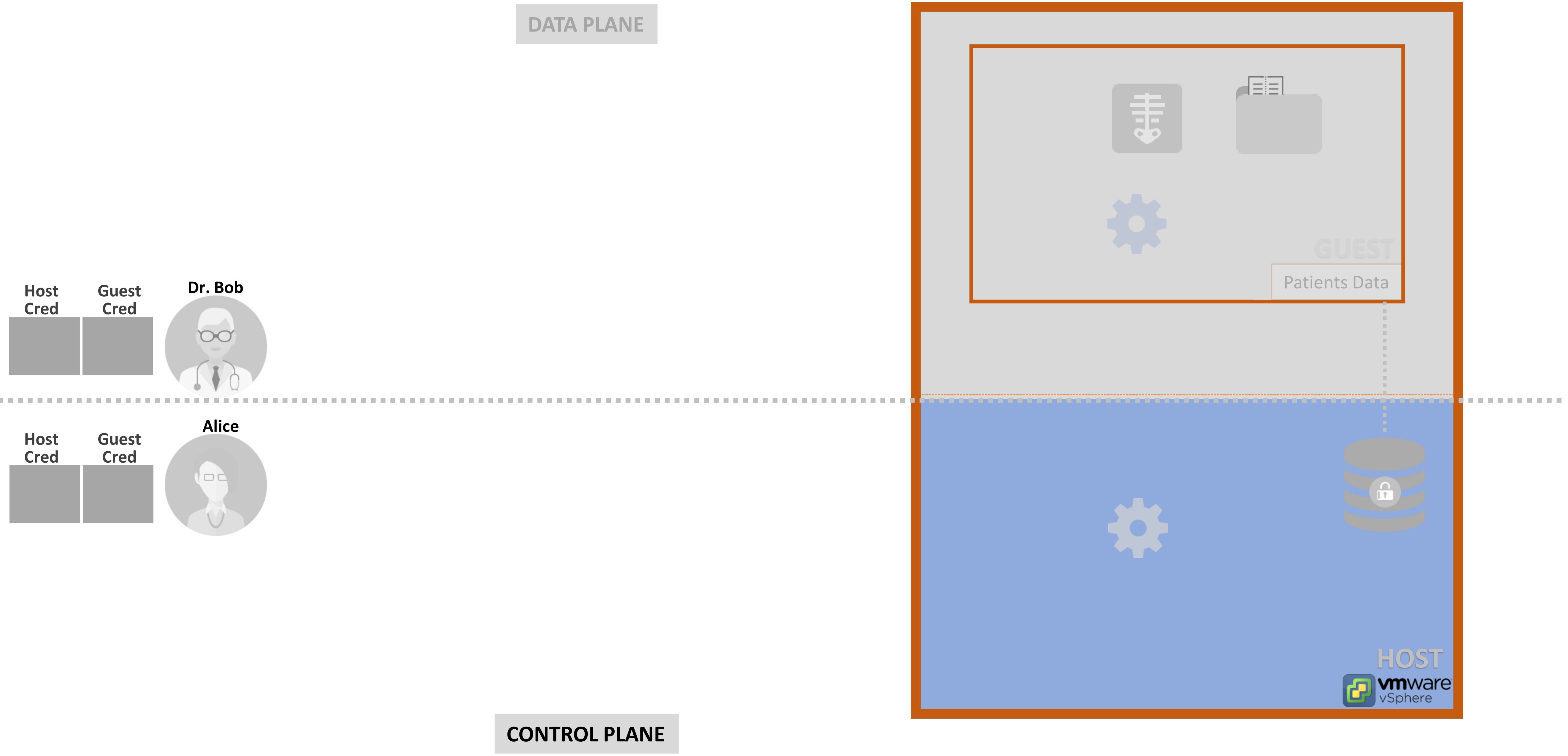
GUEST

Patients Data

HOST

vmware vSphere

CONTROL PLANE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Host Cred
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GUEST
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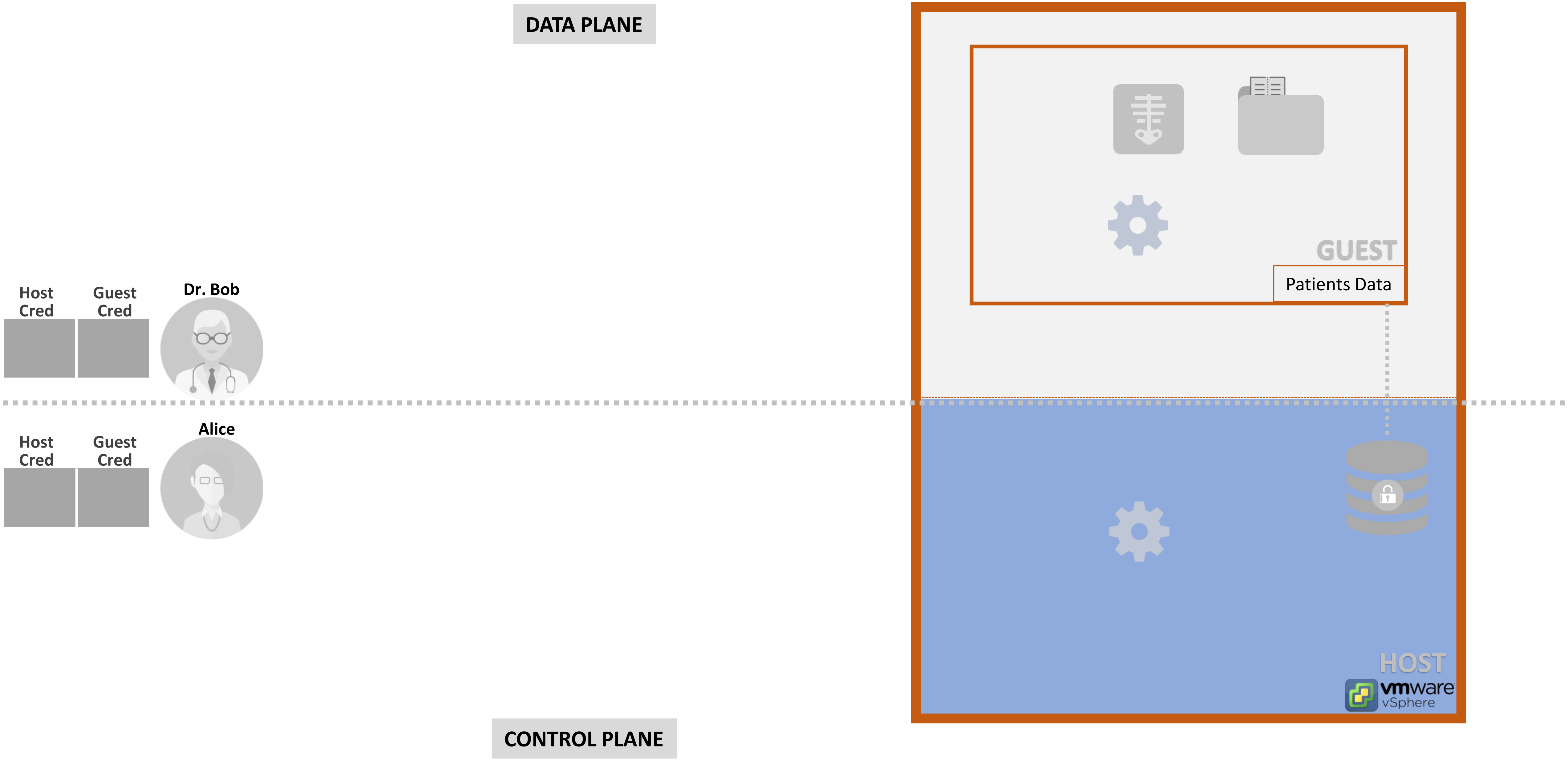
vmware vSphere
CONTROL PLANE



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vmware vSphere

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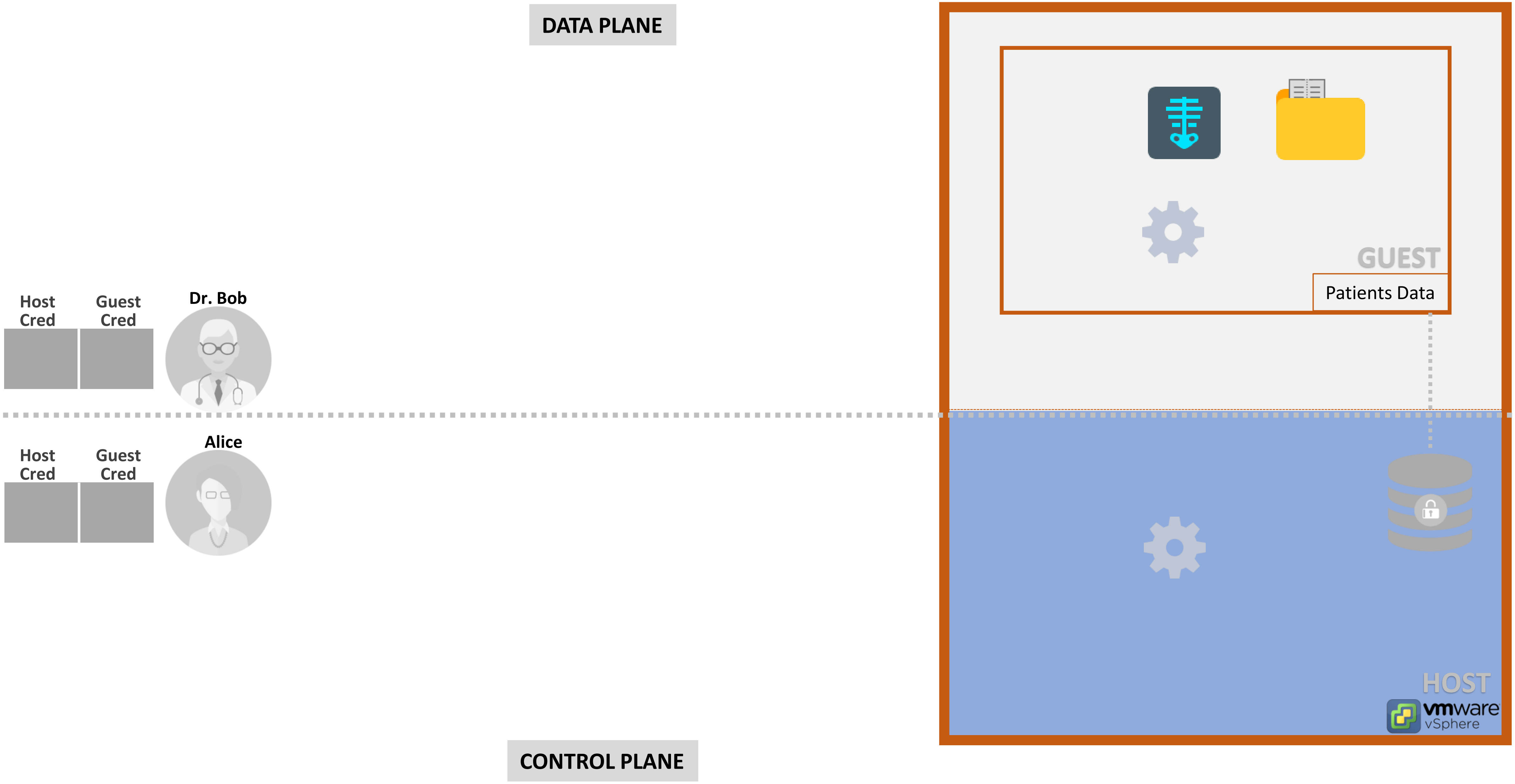

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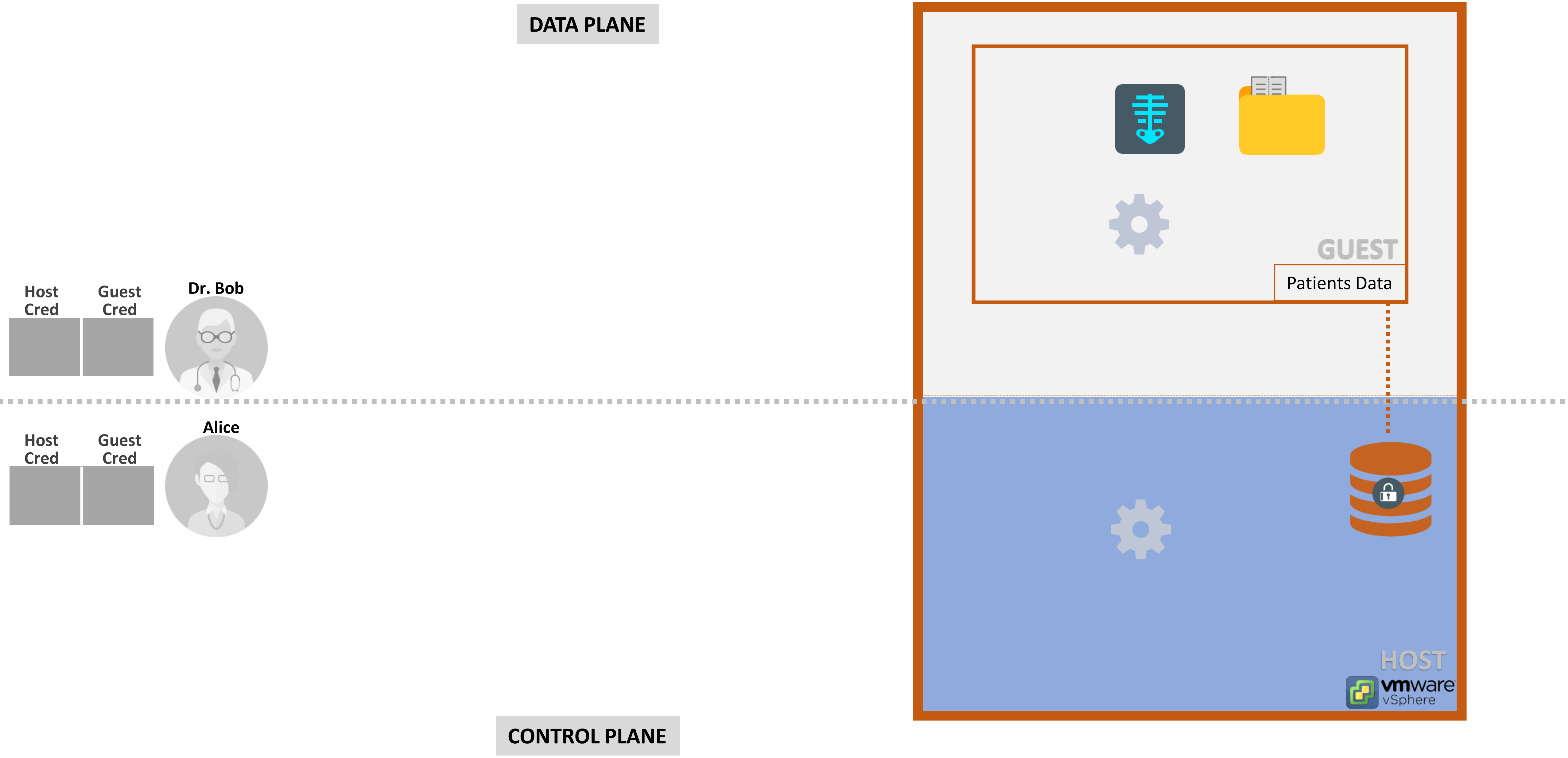
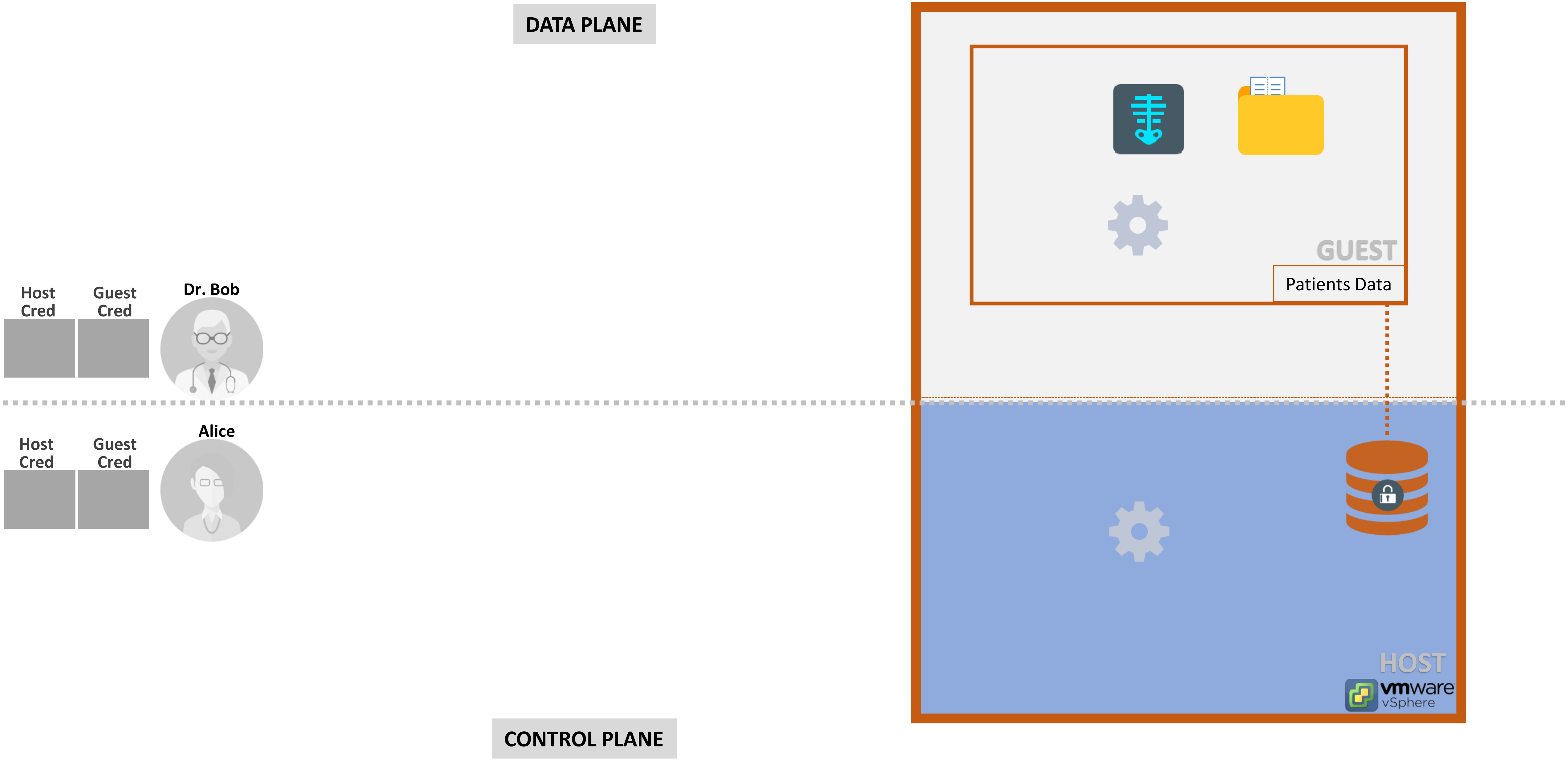
vmware vSphere

CONTROL PLANE


DATA PLANE
Host Cred
Guest Cred
Dr. Bob
Host Cred
Guest Cred
Alice
GUEST
Patients Data
HOST
vmware vSphere
CONTROL PLANE

Dr. Bob
Xray expert

Alice
Infrastructure engineer



DATA PLANE

Host Cred

Guest Cred

Dr. Bob

Host Cred

Guest Cred

Alice

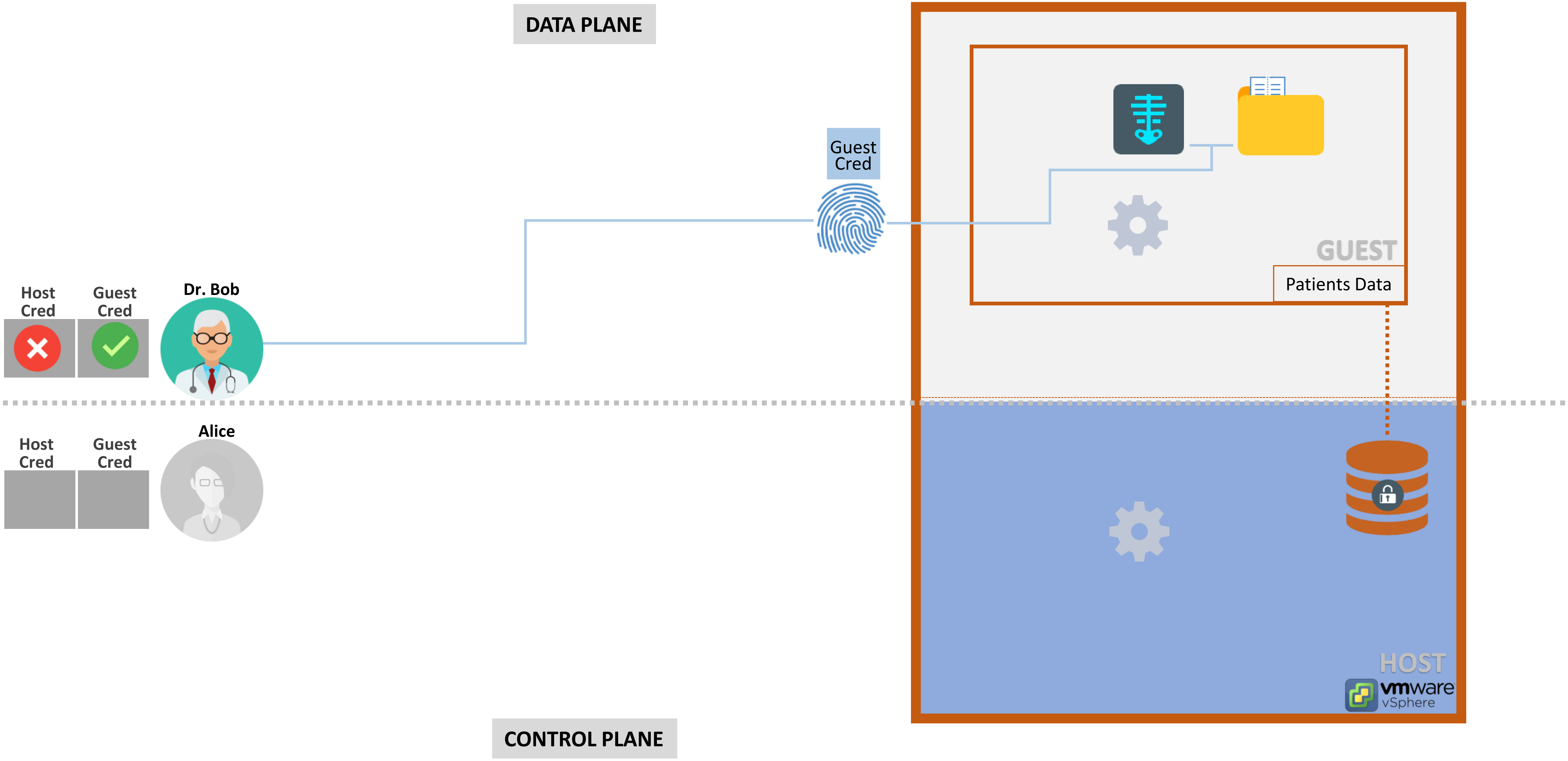
GUEST

Patients Data

HOST

vmware vSphere

CONTROL PLANE


DATA PLANE
Guest Cred
GUEST
Patients Data
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Guest Cred
Dr. Bob
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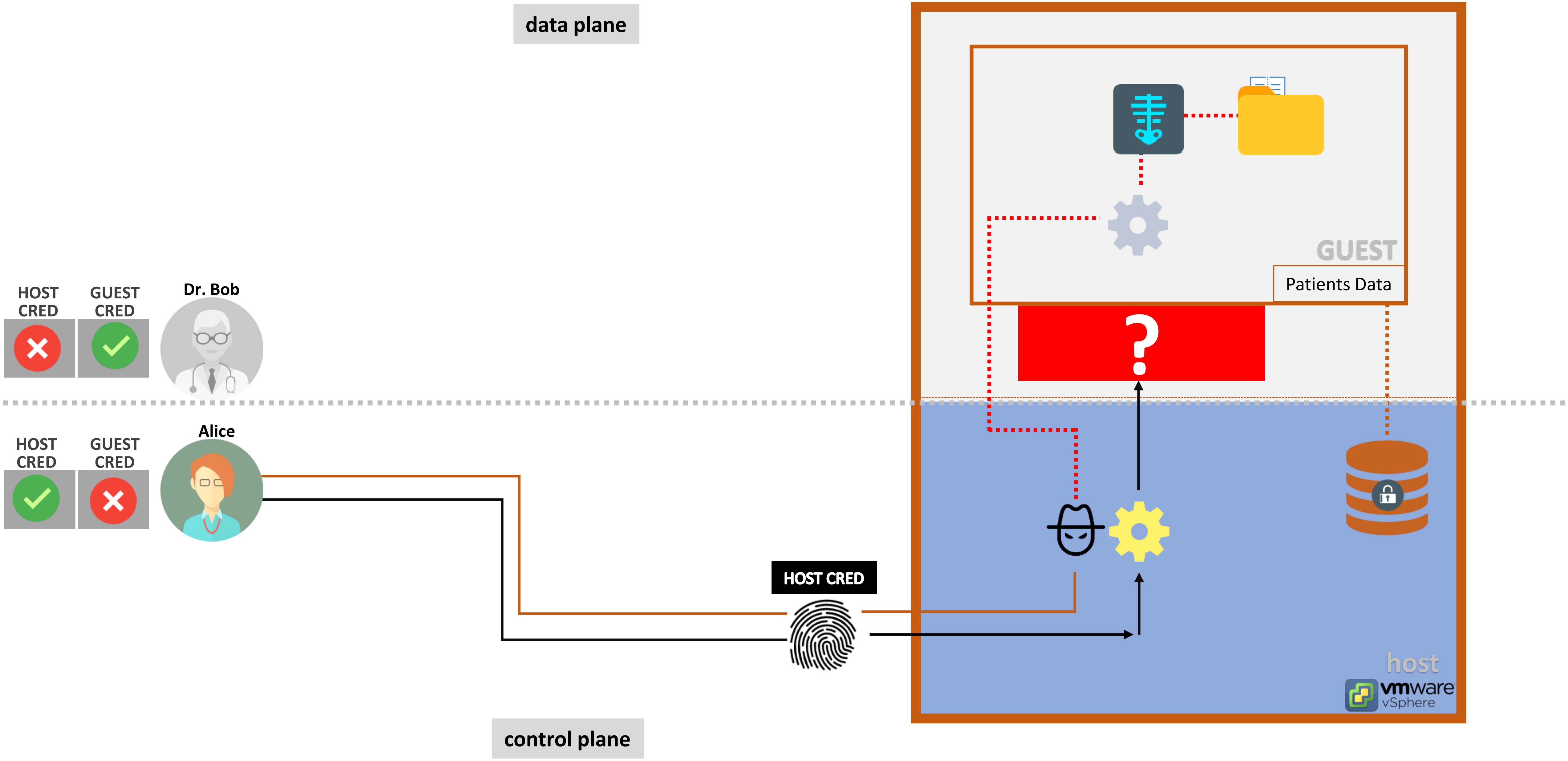
✓
Alice
Host Cred
Guest Cred
HOST
vmware vSphere
CONTROL PLANE


data plane
HOST CRED
GUEST CRED
Dr. Bob
HOST CRED
GUEST CRED
Alice
HOST CRED
GUEST
Patients Data
?
host
vmware vSphere
control plane

An undocumented feature

- Undocumented authentication method
- Bypass guest authentication
- Leads to RCE on the guest machine

Broken Host-Guest Isolation

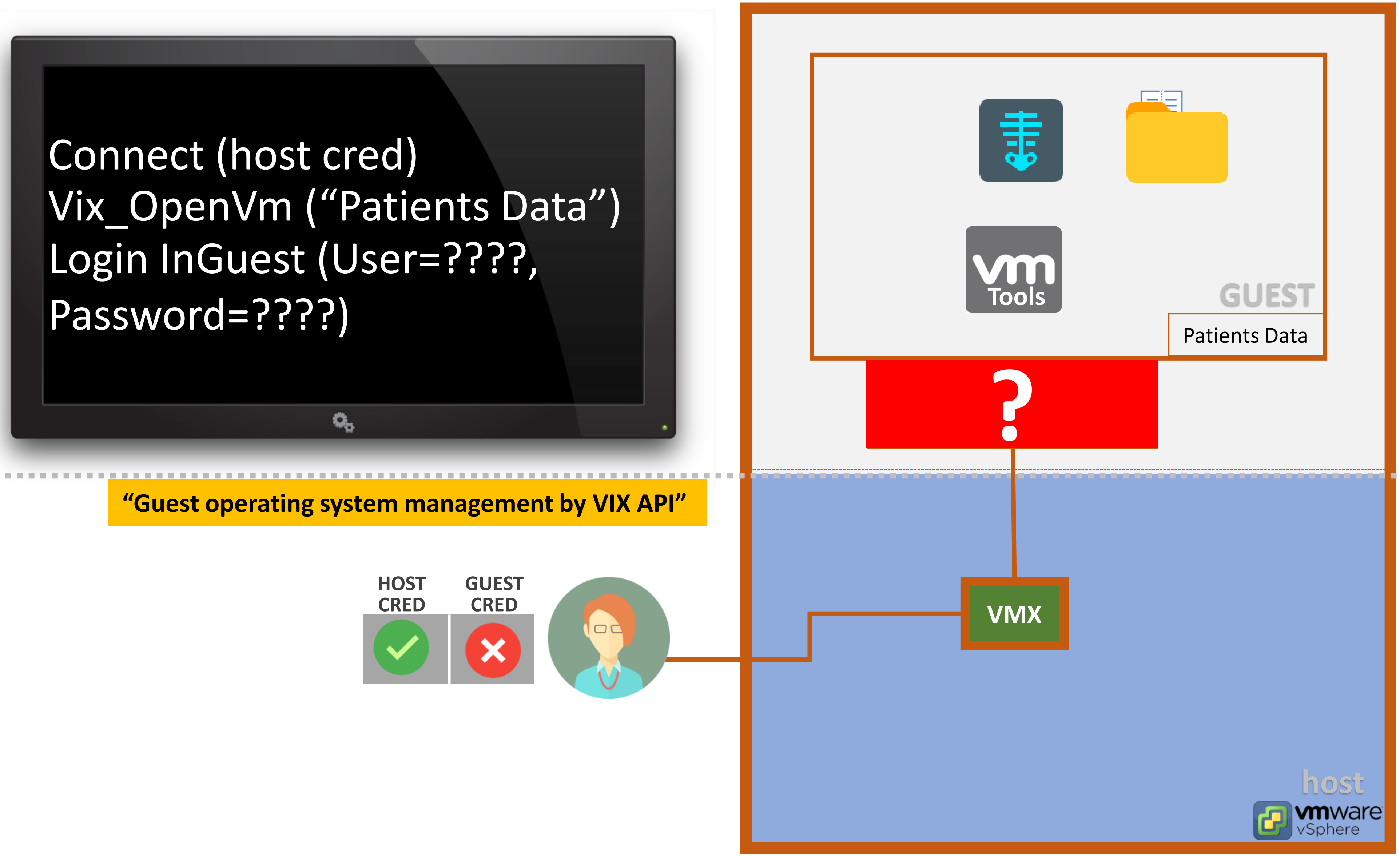
> *To user the VIX API for guest operation, applications must authenticate with two distinct security domains:*
>
> *1. The client must first **authenticate with the vSphere host**.*
>
> ~~*2. The client must then supply a **valid credential for the guest operation system** on any virtual machine where it wants to perform guest operations.*~~
>
> *- VMware*
>
> https://www.vmware.com/support/developer/vix-api/vix115_reference/security.html

All your GUEST are belong to us

- Control the guest
  - Arbitrary code execution
  - File operations
  - Registry operations

- Attack types
  - Lateral Movement
  - Access to isolated networks
  - Data leakage / manipulation
  - Ransomware

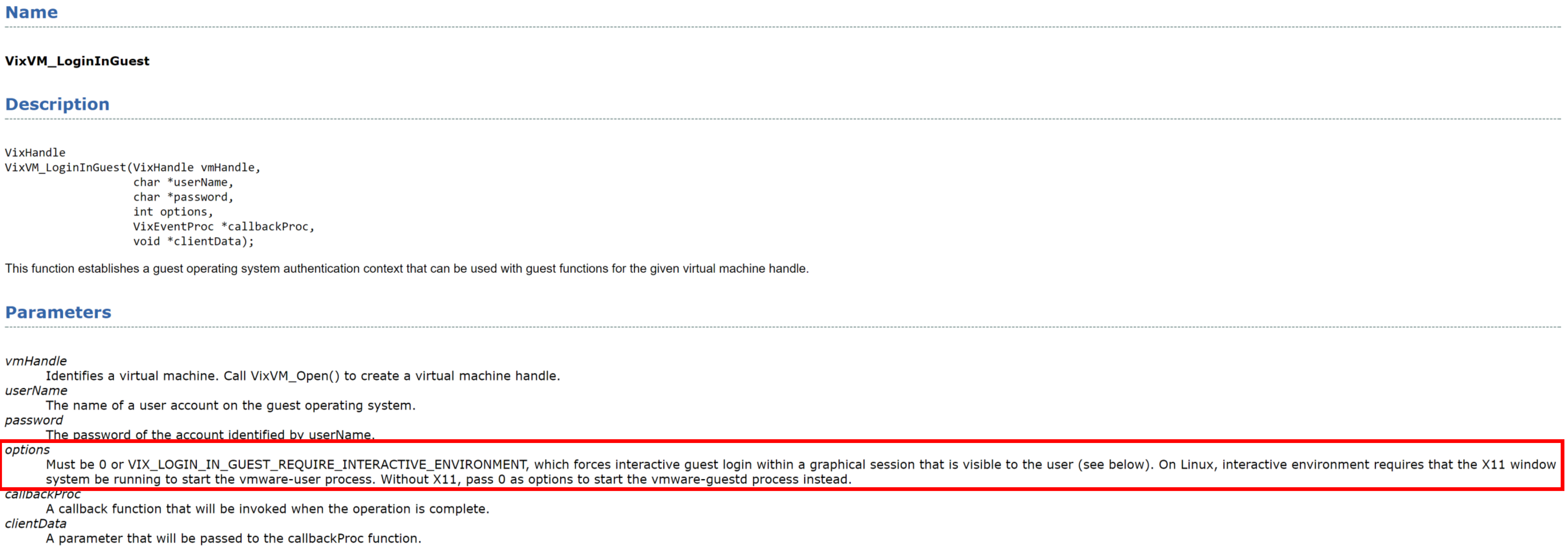
Attack Flow



Connect (host cred)
Vix_OpenVm (“Patients Data”)
Login InGuest (User=????, Password=????)

“Guest operating system management by VIX API”

Undocumented Authentication Method



Name

VixVM_LoginInGuest

Description

```
VixHandle
VixVM_LoginInGuest(VixHandle vmHandle,
                   char *userName,
                   char *password,
                   int options,
                   VixEventProc *callbackProc,
                   void *clientData);
```

This function establishes a guest operating system authentication context that can be used with guest functions for the given virtual machine handle.

Parameters

vmHandle
  Identifies a virtual machine. Call VixVM_Open() to create a virtual machine handle.

userName
  The name of a user account on the guest operating system.

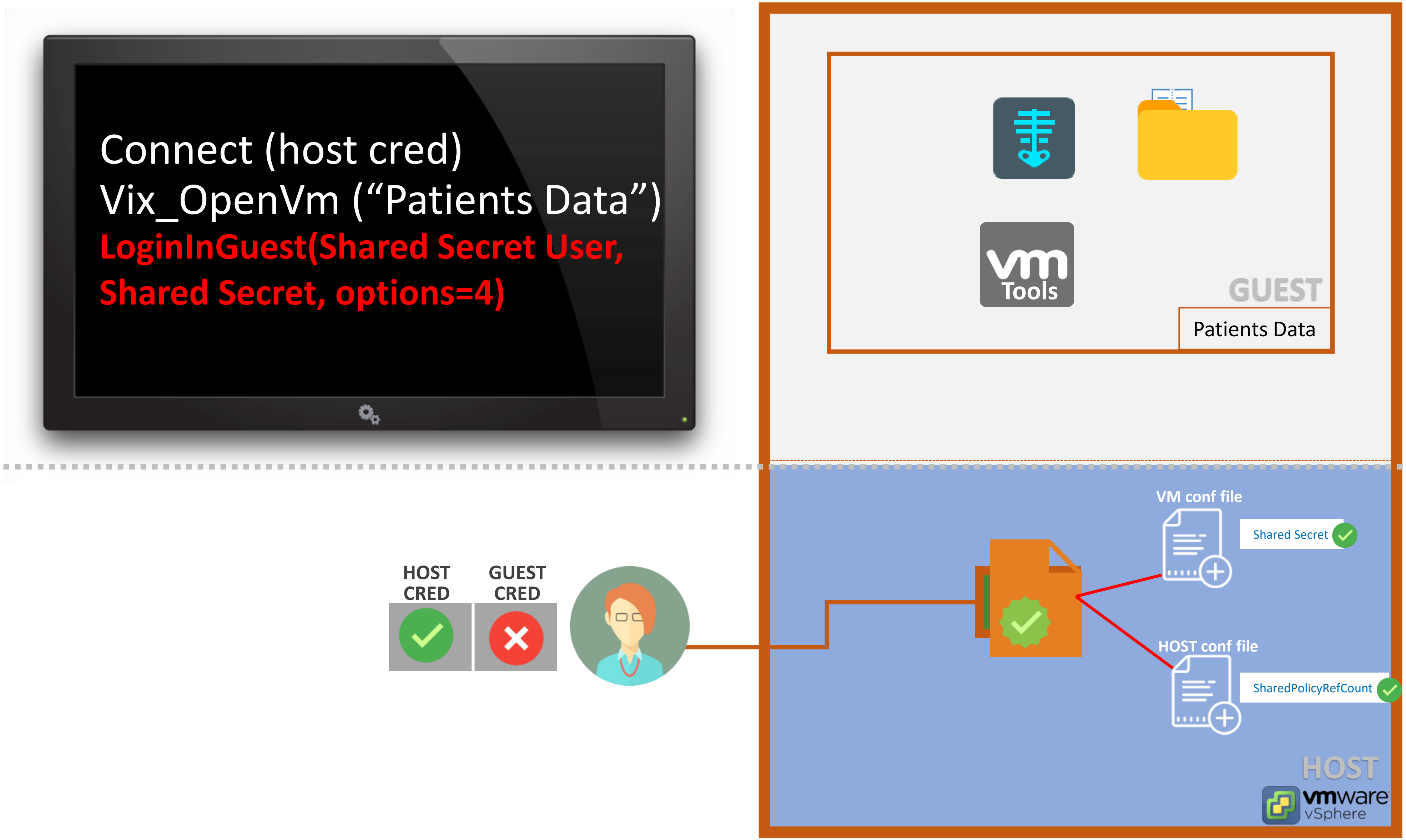
password
  The password of the account identified by userName.

options
  Must be 0 or VIX_LOGIN_IN_GUEST_REQUIRE_INTERACTIVE_ENVIRONMENT, which forces interactive guest login within a graphical session that is visible to the user (see below). On Linux, interactive environment requires that the X11 window system be running to start the vmware-user process. Without X11, pass 0 as options to start the vmware-guestd process instead.

callbackProc
  A callback function that will be invoked when the operation is complete.

clientData
  A parameter that will be passed to the callbackProc function.

Attack Flow

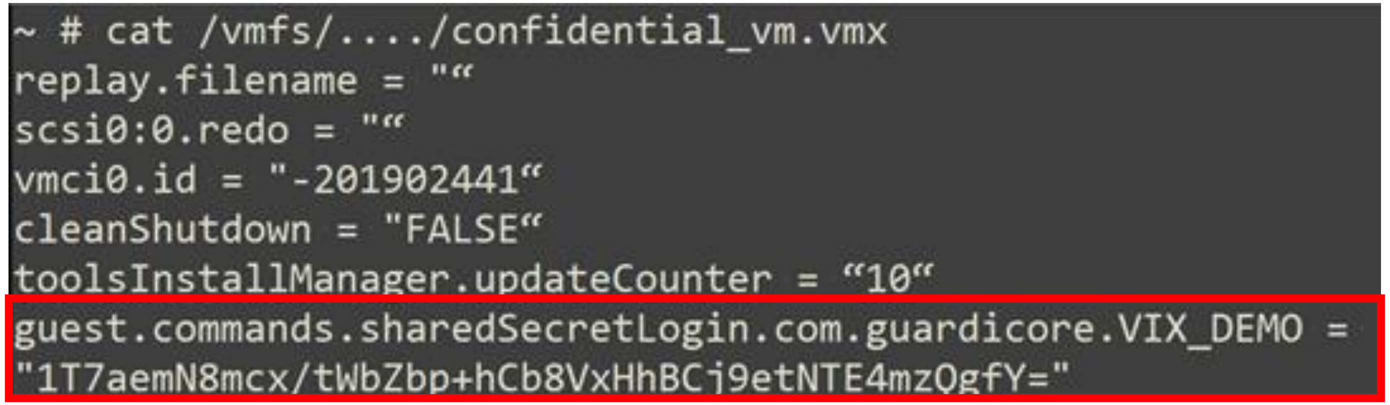


Connect (host cred)
Vix_OpenVm (“Patients Data”)
LoginInGuest(Shared Secret User,
Shared Secret, options=4)

How to Set a Shared Secret

- Shared Secret Login
    - vSphere API
    - “VirtualMachine\Config\AdvancedConfig” privilege

guest.commands.sharedSecretLogin.<USERNAME> = SHA256(SS).encode(“base64”)



```
~ # cat /vmfs/..../confidential_vm.vmx
replay.filename = "“
scsi0:0.redo = "“
vmci0.id = "-201902441“
cleanShutdown = "FALSE“
toolsInstallManager.updateCounter = “10“
guest.commands.sharedSecretLogin.com.guardicore.VIX_DEMO =
"1T7aemN8mcx/tWbZbp+hCb8VxHhBCj9etNTE4mzQgfY="
```

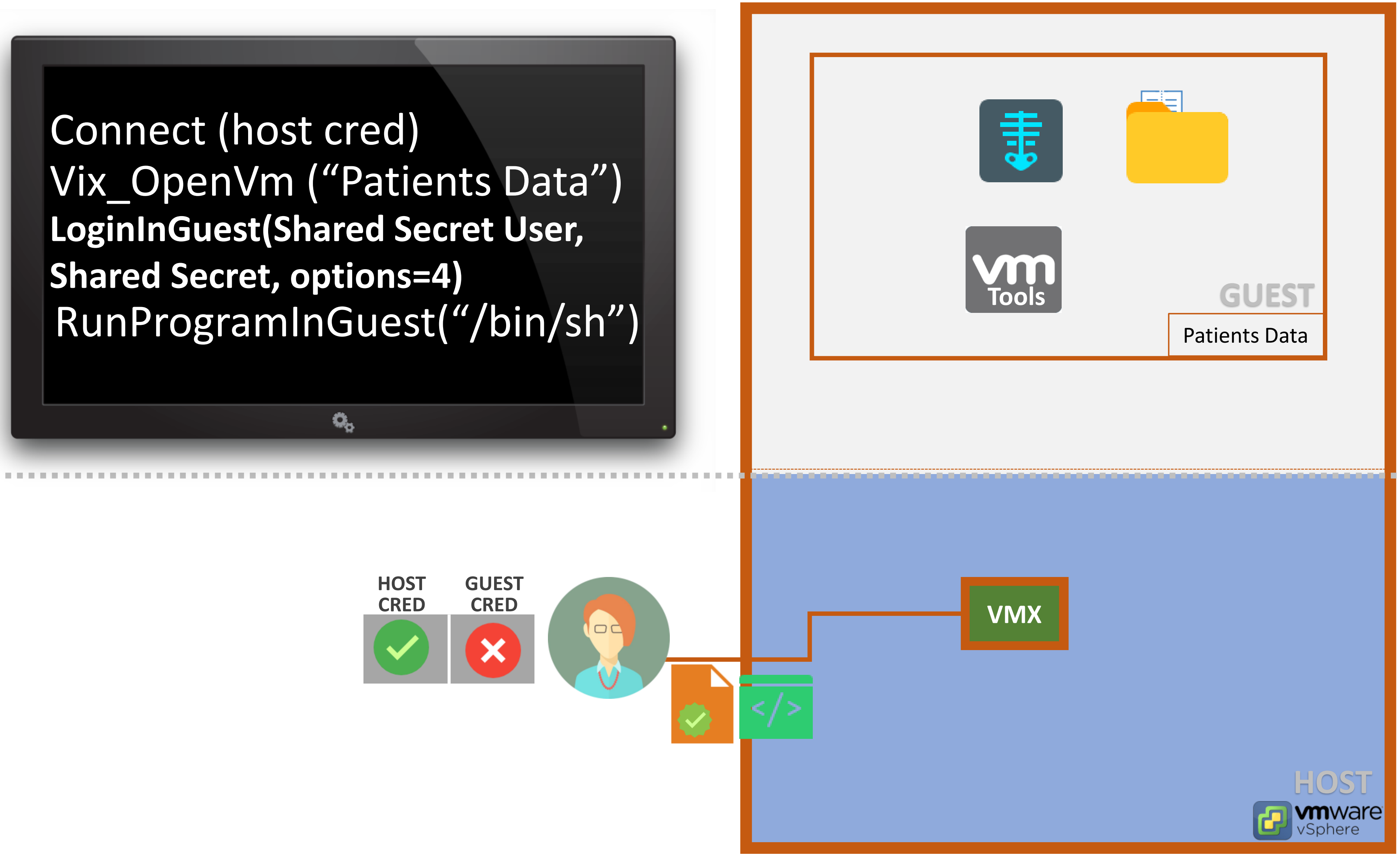
How to Set a Shared Secret

- Shared Secret Login
  - vSphere API
  - “VirtualMachine\Config\AdvancedConfig” privilege

guest.commands.sharedSecretLogin.<USERNAME> = SHA256(SS).encode(“base64”)

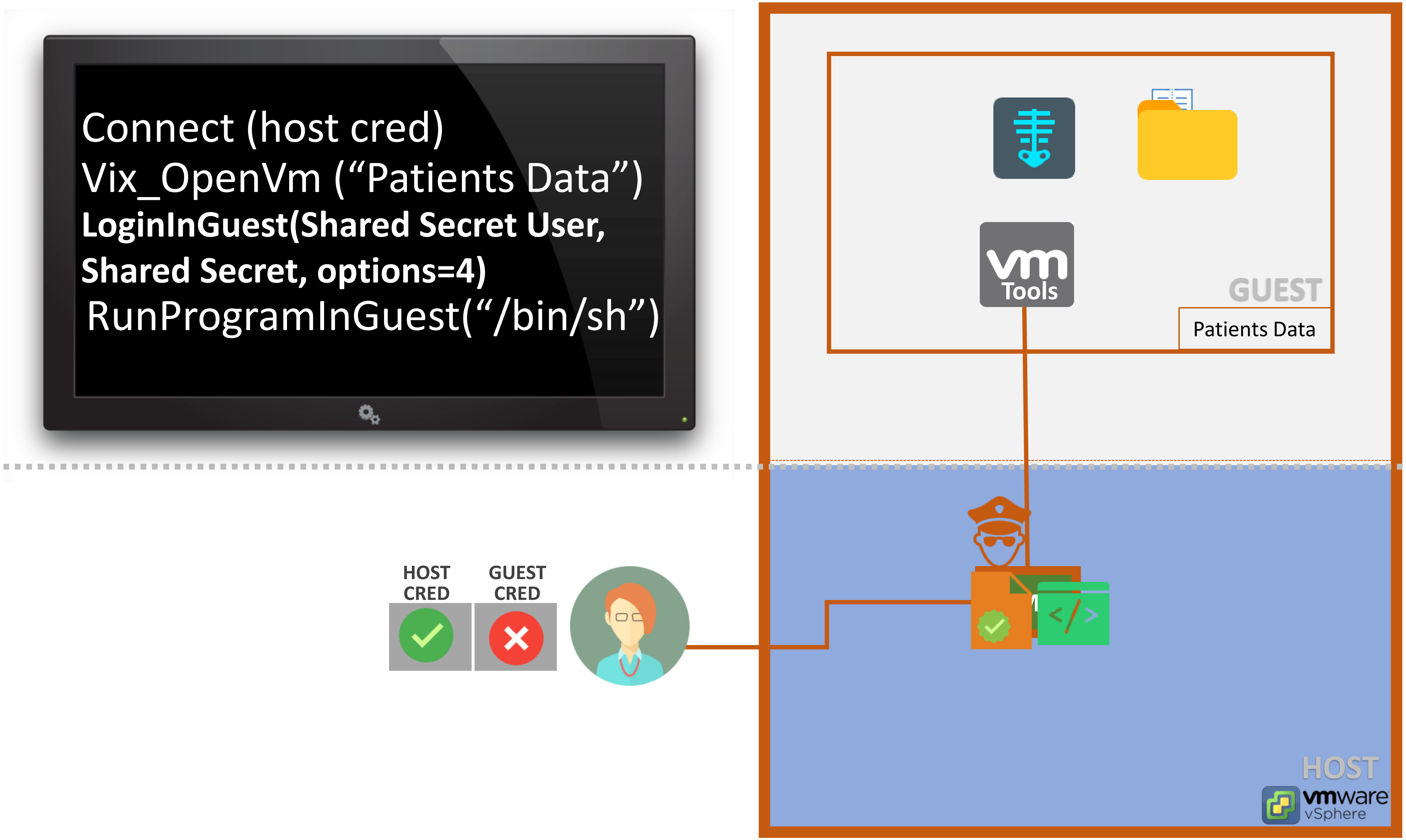
- SharedPolicyRefCount
  - Controls whether guest operations using shared secret are allowed
  - vSphere API
  - “Host\Configuration\Advanced Settings” privilege

Attack Flow



```
Connect (host cred)
Vix_OpenVm (“Patients Data”)
LoginInGuest(Shared Secret User,
Shared Secret, options=4)
RunProgramInGuest(“/bin/sh”)
```

Attack Flow



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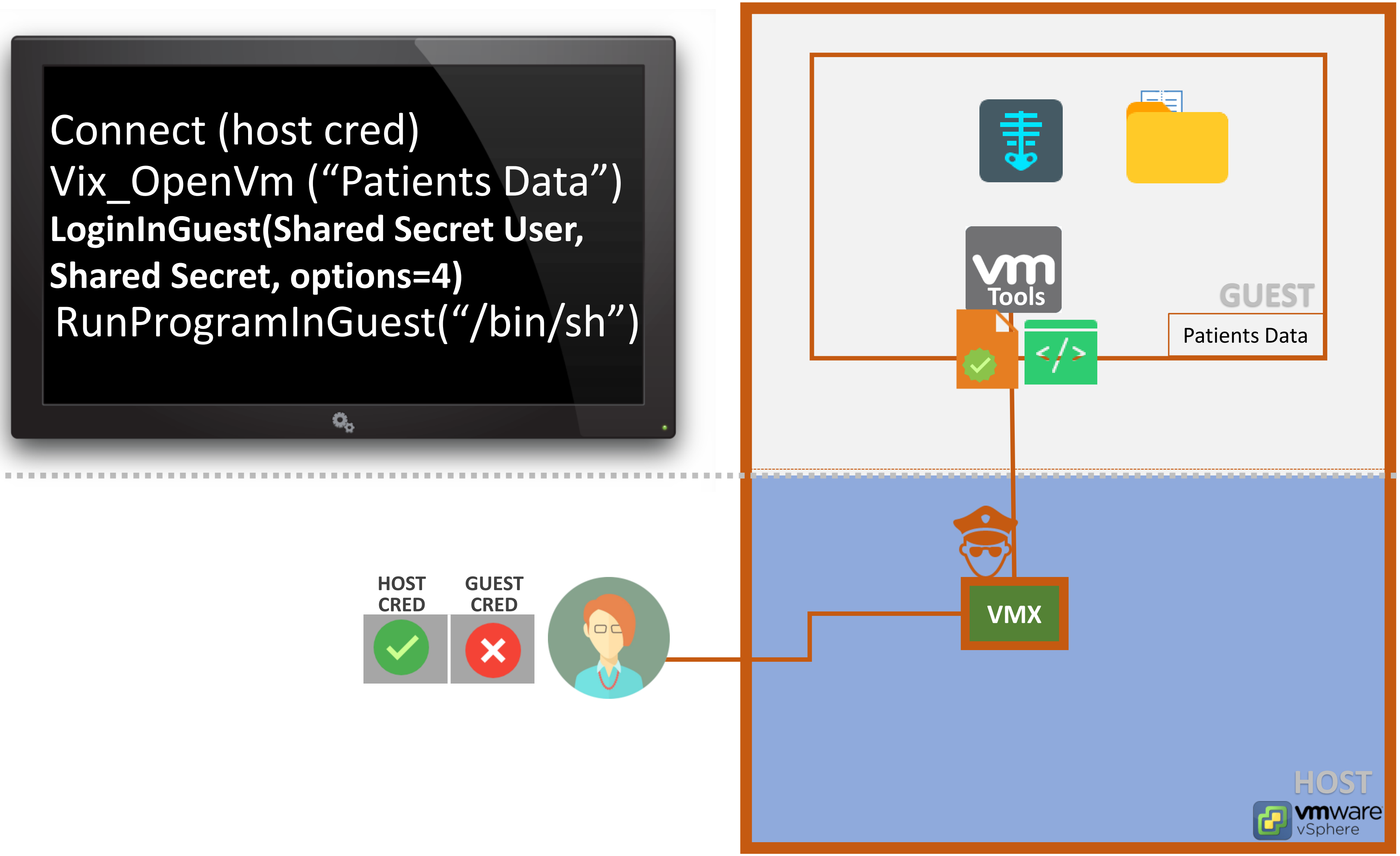
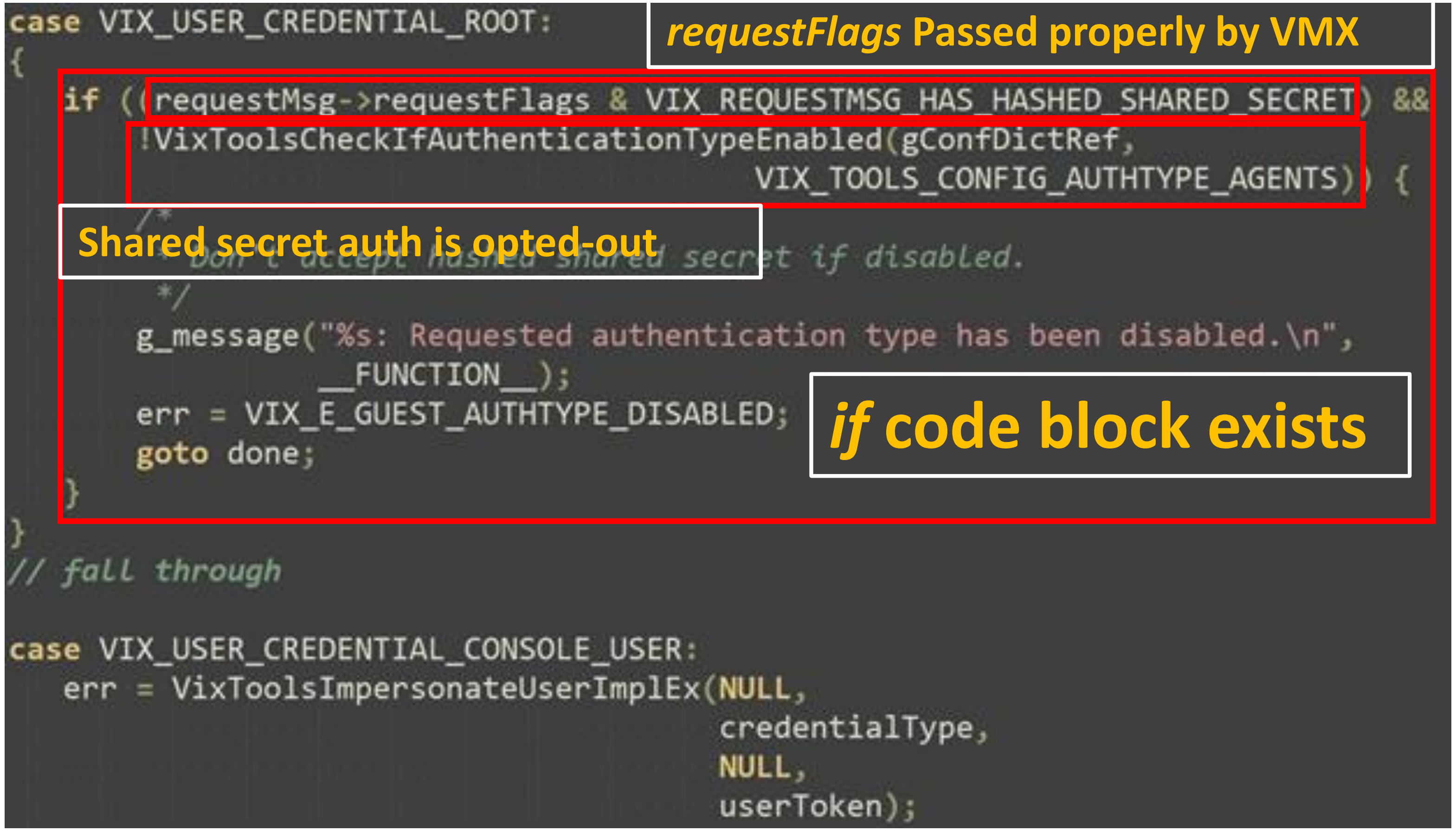
Attack Flow



```
Connect (host cred)
Vix_OpenVm ("Patients Data")
LoginInGuest(Shared Secret User,
Shared Secret, options=4)
 RunProgramInGuest("/bin/sh")
```

▶ Live DEMO!

When will the attack not work?



```
case VIX_USER_CREDENTIAL_ROOT:
{
   if ((requestMsg->requestFlags & VIX_REQUESTMSG_HAS_HASHED_SHARED_SECRET) &&
       !VixToolsCheckIfAuthenticationTypeEnabled(gConfDictRef,
                                        VIX_TOOLS_CONFIG_AUTHTYPE_AGENTS)) {
       /*
        * Don't accept hashed shared secret if disabled.
        */
       g_message("%s: Requested authentication type has been disabled.\n",
                 __FUNCTION__);
       err = VIX_E_GUEST_AUTHTYPE_DISABLED;
       goto done;
   }
}
// fall through

case VIX_USER_CREDENTIAL_CONSOLE_USER:
   err = VixToolsImpersonateUserImplEx(NULL,
                                       credentialType,
                                       NULL,
                                       userToken);
```

***requestFlags* Passed properly by VMX**

Shared secret auth is opted-out

***if* code block exists**

Who is vulnerable?

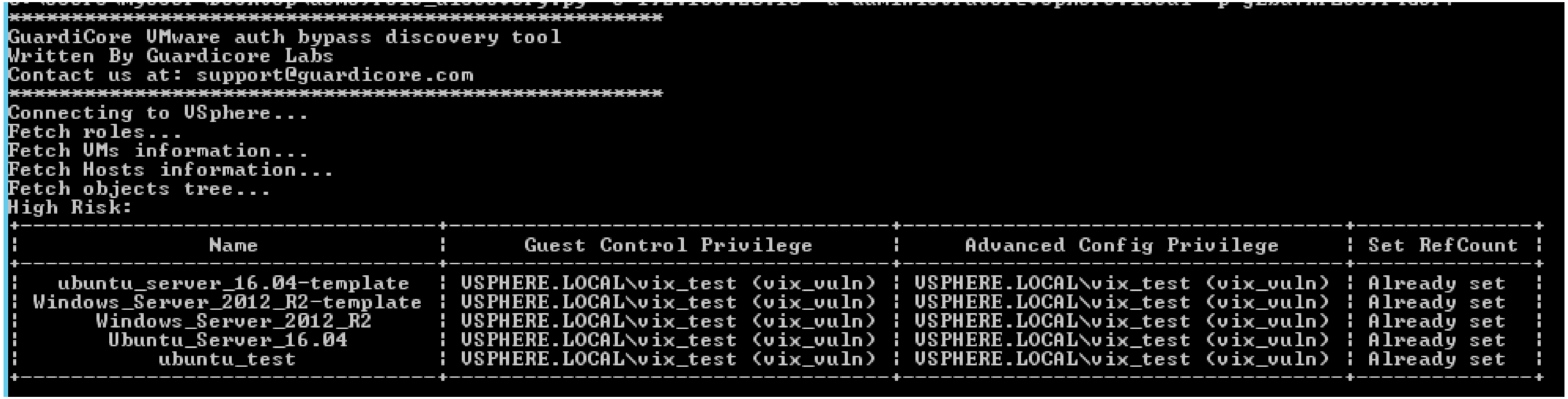
- Guest machines running on ESXi 5.5

OR

- Guest machines running VMware Tools version < 10.1.0

- Latest upstream repository offers a vulnerable OVT
  - Ubuntu 16.10
  - Fedora 25
  - RHEL 7.2
  - Oracle Linux 7 (latest)

Our Risk Assessment Tool

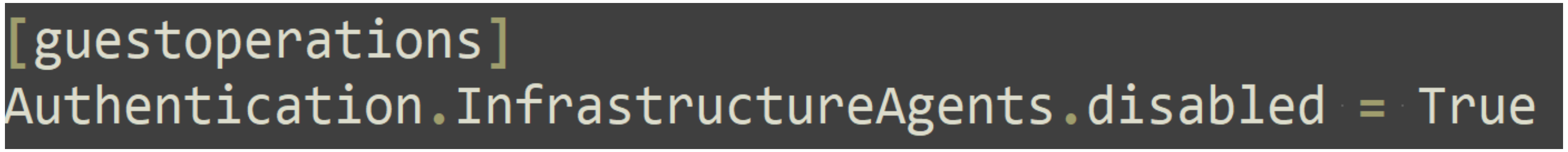


```
****************************************************
GuardiCore VMware auth bypass discovery tool
Written By Guardicore Labs
Contact us at: support@guardicore.com
****************************************************
Connecting to VSphere...
Fetch roles...
Fetch VMs information...
Fetch Hosts information...
Fetch objects tree...
High Risk:
+----------------------------------+-----------------------------------+-----------------------------------+--------------+
|               Name               |      Guest Control Privilege      |     Advanced Config Privilege     | Set RefCount |
+----------------------------------+-----------------------------------+-----------------------------------+--------------+
|   ubuntu_server_16.04-template   | VSPHERE.LOCAL\vix_test (vix_vuln) | VSPHERE.LOCAL\vix_test (vix_vuln) | Already set  |
| Windows_Server_2012_R2-template  | VSPHERE.LOCAL\vix_test (vix_vuln) | VSPHERE.LOCAL\vix_test (vix_vuln) | Already set  |
|      Windows_Server_2012_R2      | VSPHERE.LOCAL\vix_test (vix_vuln) | VSPHERE.LOCAL\vix_test (vix_vuln) | Already set  |
|       Ubuntu_Server_16.04        | VSPHERE.LOCAL\vix_test (vix_vuln) | VSPHERE.LOCAL\vix_test (vix_vuln) | Already set  |
|           ubuntu_test            | VSPHERE.LOCAL\vix_test (vix_vuln) | VSPHERE.LOCAL\vix_test (vix_vuln) | Already set  |
+----------------------------------+-----------------------------------+-----------------------------------+--------------+
```

https://github.com/guardicore/vmware_guest_auth_bypass

Mitigation

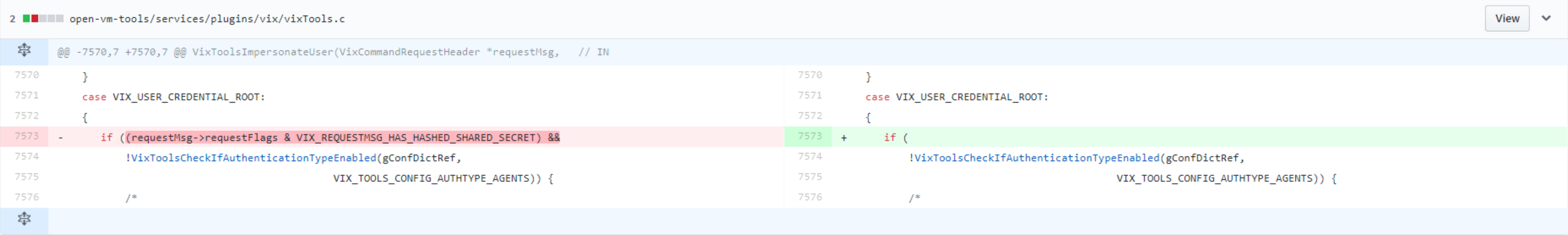
- For ESXi 6.0 and 6.5
  - Option #1 – Upgrade Vmtools ≥ 10.1.0
  - Option #2 – Opt-out by modifying vmtools configuration (for ≥ 9.9.0)



```
[guestoperations]
Authentication.InfrastructureAgents.disabled = True
```

Mitigation

- For ESXi 5.5
  - Fixed VMtools version
    - Forked from latest open-vm-tools repository
    - Source code - https://github.com/guardicore/open_vm_tools
    - Binary



2 🟩🟥⬜⬜⬜ open-vm-tools/services/plugins/vix/vixTools.c

```
@@ -7570,7 +7570,7 @@ VixToolsImpersonateUser(VixCommandRequestHeader *requestMsg,   // IN
     }
     case VIX_USER_CREDENTIAL_ROOT:
     {
-       if ((requestMsg->requestFlags & VIX_REQUESTMSG_HAS_HASHED_SHARED_SECRET) &&
           !VixToolsCheckIfAuthenticationTypeEnabled(gConfDictRef,
                                                     VIX_TOOLS_CONFIG_AUTHTYPE_AGENTS)) {
           /*
```

```
     }
     case VIX_USER_CREDENTIAL_ROOT:
     {
+       if (
           !VixToolsCheckIfAuthenticationTypeEnabled(gConfDictRef,
                                                     VIX_TOOLS_CONFIG_AUTHTYPE_AGENTS)) {
           /*
```

Go Check your network

https://github.com/guardicore/vmware_guest_auth_bypass

- Attack tool
- Risk assessment tool

Fixed vmtools version

- Source: https://github.com/guardicore/open_vm_tools
- Binary

ofri@guardicore.com

@OfriZiv (twitter)

Q&A

GuardiCore

www.guardicore.com