Ansible intro

Jan Skalny, 2025-02-19

Outline

- What is ansible
- Basic concepts
- Writing our first playbook
- Roles, Collections, Galaxies and more

Why automate?

Why automate

- Efficiency, consistency and accuracy
- Reusability between projects/organizations
- Better release engineering / DevOps practices
- Infrastructure is a cattle, not a pet
- Microservices / alternative to docker
- Detect misconfigurations and configuration drift
- Faster disaster recovery

What is ansible

- open-source automation and configuration management tool
- agentless (… kinda)
- infrastructure as a code
- define once and run many times
- avoid misconfigurations and discover deviations
- ideal for hardening, auditing and verification
- (mostly) idempotent

YAML intermezzo

- white-space has a meaning
- objects, lists, strings, …
- block scalars `|` (without new lines `>`)
- comments, begin/end doc, etc.
- transformable to/from JSON
- `yamllint` and `yq` are your friends

```yaml
user_object:
  name: "user 1"
  password: "krokodil"
  groups:
    - users
    - admins
  description: |
    this is a sample user
    description spanning
    multiple lines…
  aliases: ["user1", "foo"]

example_val: 42
```

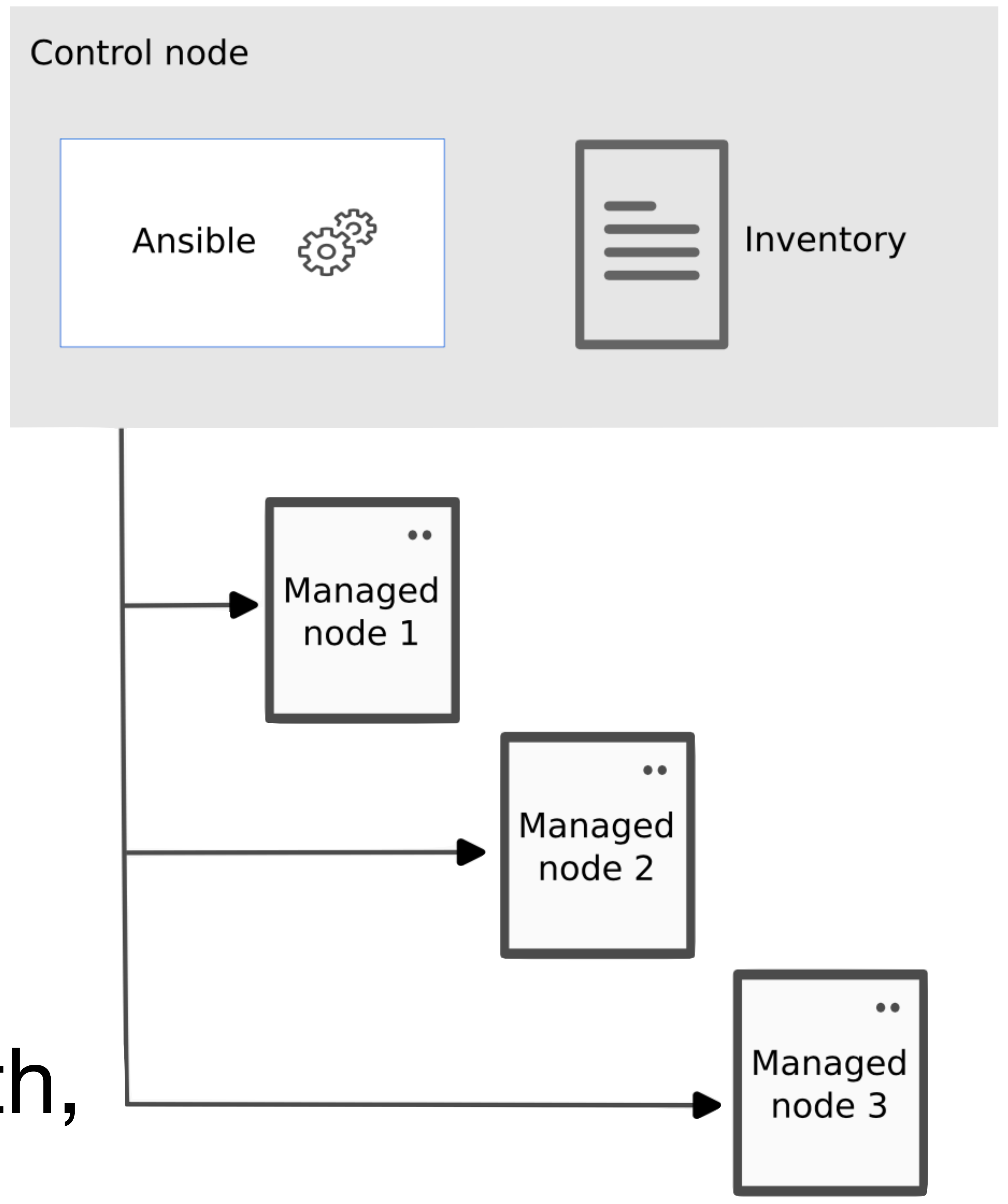
Ansible concepts

Ansible terminology

- **Control node**, where you run ansible tools,
  … uses **inventory** to group **managed hosts**
  … and define **variables** for each host.

- Executing **playbook** on managed host,
  … connects to device using ssh,
  … copies over and executes python executor,
  … generated and defined by **ansible modules,**
  … will put specific *object* on a host into desired state.

- Much of control node functionality can be tinkered with,
  see `ansible.cfg` file and `ansible-config`



* docs.ansible.com

Modules, tasks and playbooks

- **Task**
  - is single unit of work - ie. operation or desired state
  - executes exactly one ansible module
  - can succeed (either by changing something on remote system or doing nothing) or fail
- **Playbooks**
  - group, order and organize tasks into reusable and repeatable plays
  - defines desired state for each matching host
  - should be idempotent (re-running plays)
- Tasks are (usually) executed in sequence and synchronously on all matching hosts in parallel.
- Failure to execute specific task removes failing host from execution, but rest can continue.

"create directory named foo in /tmp"

```
file:
  state: directory
  path: /tmp/foo
```

```
ok=5    changed=2    unreachable=0
 failed=0    skipped=1    rescued=0    ig
```

```
check_mode: no
changed_when: False
```

strategy, serial, throttle, run_once, …

max_fail_percentage

More on playbooks

- Each **task**
  - is a YAML object with attributes
  - has exactly one **module**
  - can be named (via `name` attribute)
  - made conditional (via `when` attribute),
  - ignored when failed or run in check mode,
  - be iterated using `with_items` and `loop` attributes,
  - have custom variables defined (using `vars` attribute),
  - and much more.
- **Modules**
  - are also YAML objects,
  - implemented using specific plugin from a collection,
  - attributes are also called “parametres” to distinguish from task attributes.
  - see specific module docs for more.
- Troubleshooting typos using
  - generic yaml linters, eg. `yamllint`
  - `ansible-playbook --list-tasks` etc.
  - `ansible-lint`

```
- hosts: reverse_proxy
  environment: "{{ proxy_env }}"
  tasks:
  - name: install apache2
    package:
      name: apache2
    tags: install

  - name: enable apache2 modules
    apache2_module:
      name: "{{ item }}"
      state: present
    with_items:
    - ssl
    - proxy_http
    - headers
    - authnz_ldap
    tags: install
    notify: restart apache2

  - name: generate apache proxy conf
    copy:
      content: "..."
      dest: /etc/apache2/001-proxy.conf
    tags: configure
    notify: reload apache2

  - name: enable site
    shell: a2ensite 001-proxy.conf
    tags: install
```

Connectivity

- For unix/linux/windows systems, ansible uses ssh to upload and execute python script on target host.
- For networking devices, modules are executed locally and changes are made using ssh-cli/netconf/rest-api or in other platform specific way.
- Testing connectivity:
  1. test connectivity (and update `~/.ssh/known_hosts`)
     `ssh -v test.demo-cert.sk`
  2. check connectivity using ping module
     `ansible -m ping -i test.demo-cert.sk, all`
  3. if user name is different, use `~/.ssh/config` to define `Host` — `User` mapping,
     or `ansible_ssh_user` variable
  4. preferably, use ssh-keys for authentication (`ssh-copy-id` or modify `~/.ssh/authorized_keys`),
  5. otherwise you need `ssh-askpass` with `ansible_ssh_pass` variable

SSH Intermezzo

- ssh-keygen, ssh-add and agent
- authorized_keys and ssh-copy-id
- known_hosts
- ssh_config
- ProxyJump
- and other…

Building inventory

- Group hosts by:
  - *What* - db, websrver, firewall, …
  - *Where* - datacener, region, network segment, …
  - *When* - production, staging, test, …
- Avoid hyphens and don't start with numbers
- YAML format is more flexible than INI
- Hosts can belong to multiple groups
- Groups can be nested
- By default under `/etc/ansible/hosts`, but can be modified using `ansible.cfg` "`inventory`" variable

Sample `inventory.yml`

```
www:
  hosts:
    bit.demo-cert.sk:
    dev.demo-cert.sk:
    test[1:4].demo-cert.sk:

cluster:
  children:
    cluster_compute:
      hosts:
        c[1:3].demo-cert.sk:
    cluster_storage:
      hosts:
        s[1:2].demo-cert.sk:

kvm:
  children:
    cluster:
  hosts:
    dev.demo-cert.sk:
```

Variables

- Same naming requirements as host groups - avoid hyphens, keywords, don’t start with numerals, …
- Can be defined in multiple sources
  - Inventory - within inventory file, group_vars, host_vars, etc.
  - Playbooks (and roles)
  - Runtime - from facts, command line, registered from previous tasks, …
- Different data types available
  - Strings, Integers, Floats, Lists, Dictionaries, …
  - Booleans with “thruthly” and “falsely” values - (yes, 1, y, true, True, “True”, “yes”, “on”, 1.0, …)
  - Referencing other variables (Jinja templates), evaluated at the time of use - “{{ my_var }}/config.ini”

Separating inventory variables

- Variables can be stored separately within `host_vars` and `group_vars` directories and subdirectories
- Each host (based on `inventory_hostname`) and group can:
  - either have single host/group specific file
    eg. "`host_vars/`*`(name)`*`.yml`"
  - or better - subdirectory with multiple files.
    eg. "`group_vars/`*`(name)`*`/fw.yml`"
- Special group "`all`" can be used to define common variables for all hosts

Sample inventory with variables

```
group_vars/all/dns.yml
dns_server: "1.1.1.1"


group_vars/internal/dns.yml
dns_server: "192.168.1.1"
dns_search: "demo-cert.sk"


host_vars/dev.demo-cert.sk/dns.yml
dns_server: "147.175.159.11"
dns_search: ~


host_vars/dev.demo-cert.sk/apache.yml
apache_sites:
  - domain: www.demo-cert.sk
    owner: www-demo
  - domain: test.demo-cert.sk
    owner: www-demo
```

Variable precedence (simplified)

- "… `| default(…)`" filters
- role defaults
- `group_var/all/…`
- specific `group_var/…`
- specific `host_var/…`
- overrides from playbook
- overrides from CLI `-e …` argument
- … and much more

https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_variables.html#variable-precedence-where-should-i-put-a-variable

Using variables

- Within task attributes, using jinja “{{ variable_name }}” convention
- As conditionals (ie. when), without any escaping or jinja
- With with_items and loop iterators
- Inside templates and jinja functions…
- Use `ansible-inventory --host ...` to check defined variables

Basic modules

- Create directories and links, delete files, change permissions — `file`
- Copy files from control node to managing host — `copy`
- Manage users and groups — `user`, `group`
- Install and update software — `package`, `apt`, …

`file` module

- Tamper with remote files, links, directories etc.
- Ability to change permissions and owners/groups
    - Recursion works, but think of directories and permissions (+rX)
    - Beware of octal vs decimal permissions.
      Either use letters or don’t forget leading zero!

https://docs.ansible.com/ansible/latest/collections/ansible/builtin/file_module.html

`copy` module

- Upload or download single local file to/from remote host
  … or between two remote hosts
- Local path is relative to ansible root dir, but can be absolute path as well
- Permission/and owners similar to “`file`” module
- Instead of specifying source file, content can be in-lined with `content:`

https://docs.ansible.com/ansible/latest/collections/ansible/builtin/copy_module.html

`user` and `group` modules

- Manage accounts, groups and membership on remote os
- Can change shells, lock accounts, disable passwords for users, etc…
- To deploy `authorized_keys` file…
  either use `authorized` parameter of user module,
  or more advanced `authorized_key` module.
- Not really idempotent - deleting “unknown” accounts is more complex
- Windows needs more specific `win_user` module

https://docs.ansible.com/ansible/latest/collections/ansible/builtin/user_module.html
https://docs.ansible.com/ansible/latest/collections/ansible/builtin/group_module.html
https://docs.ansible.com/ansible/latest/collections/ansible/posix/authorized_key_module.html

Deleting unknown accounts can be a hassle

```
- hosts: all !unmanaged
  tasks:
    - name: list existing users
      check_mode: no
      shell: "getent pass[redacted]0000 {print $1}'"
      register: existing[redacted]

    - name: remove any no[redacted]
      user:
        name: "{{ item }[redacted]
        remove: yes
        force: yes
        state: absent
      with_items: "{{ existing_users.stdout_lines }}"
      when: item not in admins and not in user_whitelist
```

SKIP ME!

… for now :)

`package` module

- Manage packages using platform independent "`package`" module
  - `state: present/absent/latest`
  - Lacks ability to run "`apt-get update`" equivalent
  - Unable to perform system-wide upgrade
    or understand differences between security, feature and disruptive patches
- Platform specific alternatives, eg. `apt`, `yum`, …

Privilege escalation

- By default, ansible modules are executed in context of ssh user
- Different “`become`” methods are available using plugins
- Some require special permissions of remote host (wheel group, sudoers, …), or additional ansible variables to execute (`ansible_become_password`), or can ask for passwords using “`--ask-become-pass`" argument.
- Configured either globally (see ansible-config and ansible.cfg) or per task/playbook via variables.

```
# ansible.cfg
[privilege_escalation]
become = yes
become_method = sudo
become_user = root
```

```
# playbooks/sample.yml
- name: install sw
  package:
    name: apache2
    state: present
  become: yes
  become_method: sudo
```

```
# group_vars/webservers/become.yml
become: yes
become_method: su
become_user: www-data
```

Check mode

- Playbook can be executed in “check” mode with `-C` argument
- Useful with “show differences” mode with `-D` argument
  and for auditing and verification purposes.
- Requires idempotent tasks and modules - not always the case
- Non-modifying tasks can be executed in check mode as well
  - “`check_mode: no`”
  - useful for dynamic variable registration (see later)
- Changed result of task can be modified
  - “`changed_when: False`”
  - using conditionals and jinja is possible
- Good practice to run playbooks with ‘`-CD`’ before executing some bigger play

Using limits

fix formatting!

- Especially useful with bigger inventories or split staging/production enviros
- Applicable to:
  - playbook host selection
  - `ansible-playbook` command - to further limit playbook host selection
  - `ansible` command - to limit “`all`” statement
- All specified hosts and groups are added to set (OR)
- Ampersand “`&`” can be used to perform unions (AND), ie. select only hosts matching both groups.
- Exclamation mark “`!`” can be used to negate set (NOT). Super-useful with unions.
- Asterisk matches “`*`” and square bracket notation “`[1:9]`” also available.
- Watch out for special characters and escaping, especially CLI and !, *.

```
web mail
web:mail
web,mail
```

```
web &staging
```

```
web !staging
```

```
\!unmanaged
```

```
srv-dmz-[1:3]-*.mng-dc.*
```

```
web\*.demo-cert.sk
```

Basic modules (cont)

- Generate config files using jinja — `template`
- Modifying files in place — `lineinfile`, `blockinfile`
- rsync-ing larger data sets — `synchronize`
- Executing raw shell commands — `shell`
- `service`, `sysctl`, `reboot`, …
- And so much more…

`template` module

- Templating using jinja2 - better alternative to “copy: { content: … }”
- Conditionals
  `{% if … %} … {% endif %}`
- Iterators
  ```
  {% for x in … %}
  … {{ x.y }} …
  {% endfor %}”
  ```
- Default variables for undefined vars can be good practice
  `{% if my_var | default(“foo”) == “bar” %} … {% endif %}`
- White-space trimming possible using “`-`“, but maj. PITA. eg. “`{%-`“,
- Source file relative to ansible root dir or role dir (see later)
- Custom functions, filters, matching, variable registration, includes and much more!

https://docs.ansible.com/ansible/latest/collections/ansible/builtin/template_module.html

Modifying existing files

- Alternative to generating whole file using template (jinja)
- Necessary for files managed by different roles/tasks and users
- Avoid if possible, since it's harder to maintain consistency and idempotency
- `lineinfile` and `blockinfile` module
- Match text using `regexp:` `insertbefore:` `insertafter:`
- Can change permissions as well

https://docs.ansible.com/ansible/latest/collections/ansible/builtin/lineinfile_module.html

`synchronize` module

- Requires `rsync` installed on both managing and remote node(s)
- Possibility to run between nodes as well
- Compression, special fs flags and more/

https://docs.ansible.com/ansible/latest/collections/ansible/posix/synchronize_module.html

`shell` module

- “Hammer” when something needs bashing :)
- Execute shell script on remote host and record results (`stdout`, `stderr`, `rc`)
- Always marked as “changed”
  Use `changed_when` and `failed_when` to parse outputs using conditionals.
- Good for additional “facts” gathering
  Don’t forget `changed_when: false` and `check_mode: no` to run in `-CD`.
- Avoid if not necessary, but often useful if module does not exists
  - `reboot:` vs `shell: shutdown -r now`
  - `docker_compose:` vs `shell: docker compose up -d`

Task iterators using `with_items`

- Tasks can be easily repeated using items iterator.
- Define `with_items` attribute with list for strings/objects/…
- Tasks gets executed for each item from the list,
  with new “`item`” variable defined.
- Beware or `include` and and nested `with_items`.
  Can cause variable confusion / overwrite.
  Use `loop` … `with` instead.

Registering variables

- When executed, modules produce results (success/fail, stdout, objects, etc.)
- These can be stored into host-specific variables using `register:` attribute, and later used in conditionals or templating.
- Variables are ephemeral and host specific
- If necessary for playbook, non-modifying tasks must be run in check-mode, using “`check_mode: no`”
- Alternatively some tasks can be skipped or ignored in check mode

Deleting unknown accounts can be a hassle

```
- hosts: all !unmanaged
  tasks:
    - name: list existing users
      check_mode: no
      shell: "getent passwd | awk -F: '$3 > 1000 && $3 < 10000 {print $1}'"
      register: existing_users

    - name: remove any non-defined but existing users
      user:
        name: "{{ item }}"
        remove: yes
        force: yes
        state: absent
      with_items: "{{ existing_users.stdout_lines }}"
      when: item not in admins and not in user_whitelist
```

Facts and magic variables

- Special set of variables automatically defined at start of playbook execution, or when specifically requested using “`gather_facts`” module.
- Can be cached locally or disabled for faster execution
- Useful for conditional playbooks and roles (eg. platform specific configuration)
- Example:

```
ansible -m gather_facts -i test.demo-cert.sk,
```

https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_vars_facts.html

Registering variables — `set_fact`

- Using `set_fact` module to define variable on the fly
- Transform dynamic or complex variables using jinja2 filters
- Troubleshooting can get more difficult, and reusability will suffer

```
  - name: Extend cortex_analyzers with default configuration
    set_fact:
      cortex_analyzers: "{{ cortex_analyzers | default([]) + [ {
        'name': item.name,
        'rate': item.rate | default(None),
        'rateUnit': item.rateUnit | default(None),
        'jobCache': item.jobCache | default(cortex_default_jobCache),
        'jobTimeout': item.jobTimeout | default(cortex_default_jobTimeout),
        'configuration': cortex_default_configs | combine(item.configuration |
```

Registering variables — `include_vars`

- Dynamically using `include_vars` module
- Good for platform specific variable definition

```
- name: set distro-specific variables
  include_vars: '{{ item }}'
  with_first_found:
    - '{{ ansible_os_family }}.yml'
    - default.yml
```

Debugging

- Dumping host variables using:
  `ansible-inventory --host xxx`
- Using `debug` module within playbooks,
  referencing `vars` or `hostvars[…]` variables.
- CLI tools accept “`-v`” verbosity argument (multiple times to increase level).
- Modules can have `verbosity:` attribute set.
- Running in check mode and diff mode first `-CD`
- lint-ers are your friends, especially with YAML files

How to get ansible - easy way

- Use your OS-es native package manager, eg.
  ```
  brew install ansible
  apt-get install ansible
  ```
  - less control over ansible version you get :(
- Or, install python w/ pip and run
  ```
  pip3 install ansible
  ```
  - dependencies are a hassle :(
- Or, use existing docker container. eg.
  ```
  docker run --rm --it willhallonline/ansible /bin/sh
  ```
  - … and suffer when mounting ssh auth socket from you MacOS host :(

Our lab environment

- `git clone https://github.com/JanSkalny/fiit-bos-ansible.git`
- `docker compose up -d`
- `docker run --work /root/ --it ansible bash`
- See README.md for more

Advanced concepts

More on playbooks

- Playbooks can contain multiple blocks of hosts+tasks
- Failing within one block DOES NOT remove host from next block of tasks.
- If something needs to be executed before main roles/tasks, use `pre_tasks`: (important when mixing roles, see later)
- If something needs to be executed after main roles/tasks, use `post_tasks`: (usefull for cleaning up after failed executions)
- For single-shot conditional tasks, use `handlers` and `notify` (see later).

sample playbook with multiple blocks, post_tasks and handlers

Handlers

- Occasionally some tasks need to be executed:
  - conditionally (only when something is changed),
  - once (multiple tasks might need same after-action),
  - and at well defined time.

  Example: restarting apache service after modifying files or installing new modules
- Tasks that need to run specific handler (or handlers), can use “`notify:`”
- For each notified item, `handler` must be defined:
  - either within playbook,
  - or in executed role.

https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_handlers.html

Task iterators using `loop`(s)

- Better version of `with_*` iterators.
- Define list of objects or strings using “`loop`” attribute
- Iterator variable can be renamed using attribute
  `loop_control: { loop_var: my_var }`
- Results can be registered into “`results`” list variable

Conditionals

- As task attributes:
  - `when:` to limit task execution
  - `changed_when:` to ignore or improve “changed” detection (especially useful with generic modules, such as shell)
  - `failed_when:` to mark tasks as failed depending on result / condition
- Combine `when` with `loop:`(s) for filtering of items.
- Conditional variable inclusion is also possibe via `vars_files`
- Beware of conditional imports/includes (see later)

Roles

- Separate functionality and related templates, files, variables and handlers into easily shareable entity
- Included directly in playbook using `roles:` attribute,
  or by using `include_role` module (with `loop`s and other goodies)
- Roles are loaded from collections, `roles/` directory or `role_paths` - in that order.
- When writing roles:
  - do define sensible defaults for most variables (eg. api versions, ports, generic db names, …)
  - don’t define defaults for variables that have to be supplied by user (eg. api_keys, urls, …)
  - don’t produce too generic roles (with many variables, supporting every possible patform, …),
  - don’t produce roles that take more time to configure, than it takes to reimplement them,
  - make sure they are compatible with most ansible configurations (no exocit depends, hash_beh.),
  - do write documentation, readme, commented defaults, tests, etc..

Roles (cont.)

- Typical role structure:
  `tasks/main.yml` main playbook - may include additional files
  `defaults/main.yml` default variables
  `handlers/main.yml` dictionary of all handlers used within role
  `vars/main.yml` other vars used by role (good for platform specific stuff)
  `templates/` and `files/` source directories for `template` and `copy` modules
  `meta/main.yml` for role depdendencies, author and version information, etc.
  `README.md` :)
- Newer versions allow args validation using `meta/argument_specs.yml`

Includes vs imports

- Import - evaluated at parse time (when starting play)
- Include - evaluated when executed (when task gets reached)
- Include is more suitable for looping, but has drawbacks:
  - `--list-tags` does not work,
  - `--start-at` does not work,
  - handlers from included roles/plays are not considered,
  - tags are applied only to “include”, not “included”, …
- Read more later…
  https://docs.ansible.com/ansible/2.9/user_guide/playbooks_reuse.html

Speeding up (re)execution

- Use `ansible-playbook —start-at="task name"` when developing playbook or when something breaks “somewhere in the middle”. But beware of dynamically defined variables.
- Limit execution to retry file using `-l @playbooks/xxx.retry` (must enable retry_files_enabled in ansible.cfg)
- Use tags for configuration only steps (see later)
- Use imports instead of includes
- SSH pipelining, forks, control paths, timeouts and retries
- Mitogen?
- Benchmark your network, ssh and for global “`become: yes`” consider using root.

Tags

- Every task within play or role can be tagged with one or more tags
- Tags can be applied also to `block:` of tasks or whole playbook.
- `ansible-playbook` allows skipping (`--skip-tags`) or running only tasks (`-t`) with specific tags.
  See `ansible-playbook --list-tags` and `--list-tasks`
- Beware of nested tasks (includes vs imports)!

https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_tags.html

Strategies, serialization and async

todo

More modules

- ansible-core (built-in) modules
- Generic and platform specific modules
- Collection specific modules
- https://docs.ansible.com/ansible/latest/collections/index_module.html

Advanced concepts pt. 2

Chicken and egg problem

- Installing ansible dependencies using ansible?
- Initial playbook
  - with `gather_facts: no`
  - and “`raw`” module to run shell commands…
  - install python3 and dependencies…
  - (pre)modify sudoers…
  - install authorized_keys…

```
- hosts: all
  environment: "{{ proxy_env }}"
  gather_facts: no
  tasks:
  - raw: apt-get install -y --force-yes -o "Acquire::http::Timeout=10" --no-upgrade python3-apt
  - raw: pkg install -y python
  - raw: yum install -y python
```

To be continued…

- Collections
- Galaxies
- ansible-vault
- tower / AWX
- dynamic inventories
- …

Collections

Galaxies

ansible-vault

How to get ansible - better way

venv, pip, docker

Ansible tower / AWX / semaphore

Dynamic inventories

jinja hacks

- merging variables :)
- filters
- custom functions

Conclusions

Conclusions