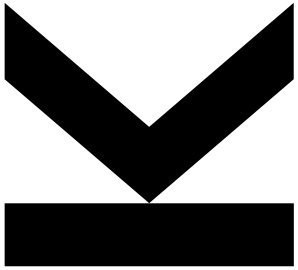
FEATURE-ORIENTED AND DISTRIBUTED VERSION CONTROL SYSTEM



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Austria

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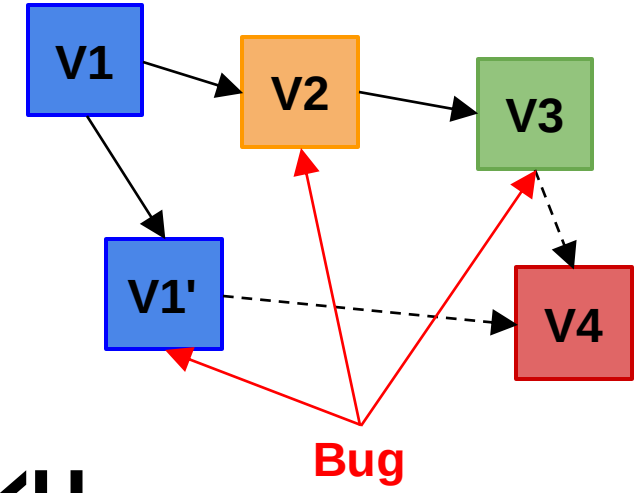
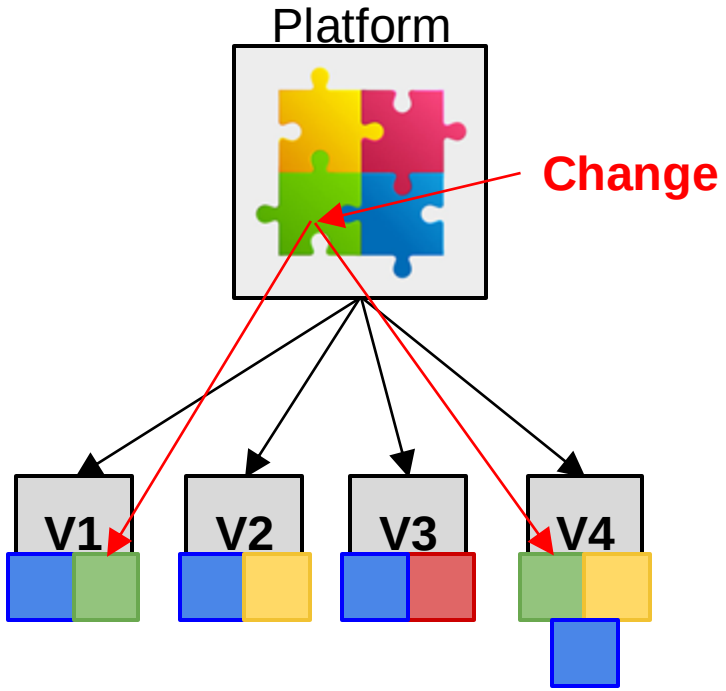
UNIVERSITY LINZ

VARIABLE SYSTEM DEVELOPMENT

- **Ad Hoc Approach** (Clone-and-Own): Separate implementation for every product variant
  - Multiple variants of the same product must be maintained
  - Difficult to reuse existing implementation

- **Structured Approach** (SPLs): Common platform that realizes the product and its variability
  - Multiple versions of the same feature must be maintained
  - High upfront costs of time and money
  - Difficult to extend and modify the platform

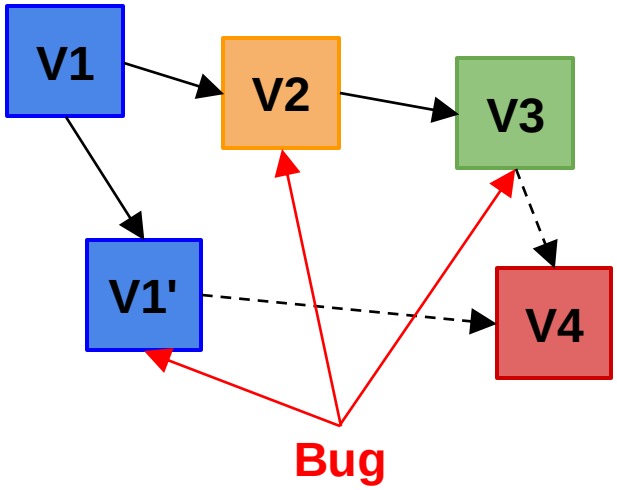




AD HOC APPROACH (CLONE-AND-OWN)

Separate implementation for every variant

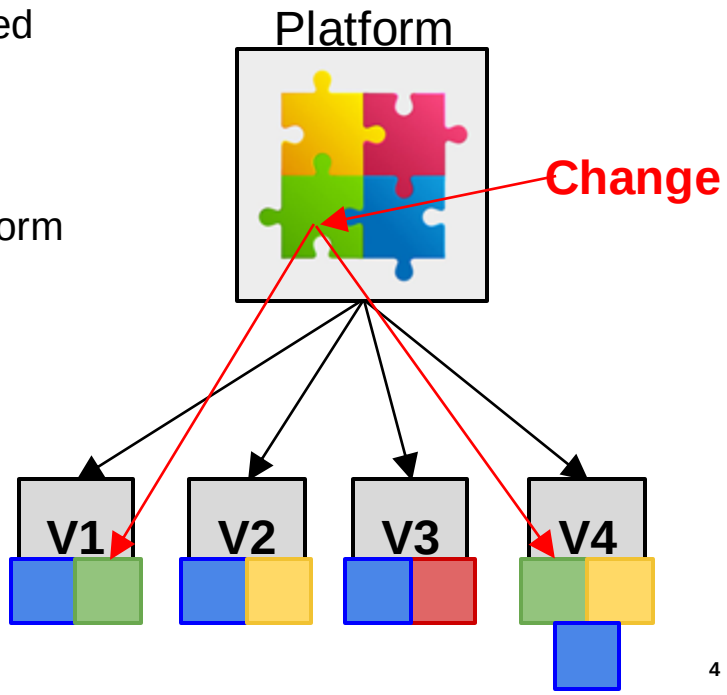
- Example
  - Company builds an initial product and sells it to a customer
  - New customer wants the same product but a bit different
  - Another customer requests a combination of both → difficult reuse
  - A customer reports a bug in its variant → difficult maintenance
- Multiple variants of the same product must be maintained
- Challenges
  - Reuse of implementation
  - Maintenance of the variants



STRUCTURED APPROACH (SPL)

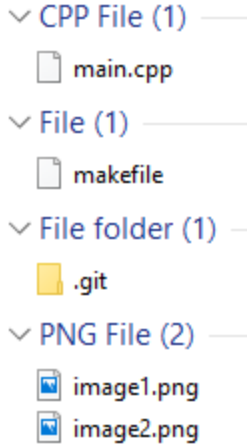
Common platform that realizes the system and its variability

- Example
  - Company carefully plans and builds a product platform
  - Derives variants with different features for different customers
  - One customer wants an existing feature to behave differently → difficult change
- Multiple versions of the same feature must be maintained
- Challenges
  - Upfront costs of time and money
  - Extension and modification (i.e. evolution) of platform



MOTIVATION

- Systems that consist of different types of implementation artifacts
- Different variability mechanisms for different types of implementation artifacts
  - *preprocessor* for text-based artifacts
  - runtime constructs of programming language
- Different mechanisms at different levels of granularity
  - *make* at file level
  - *preprocessor* below file level



- Challenges
  - inconsistencies between mechanisms
  - difficult to find mechanisms for some types of artifacts
  - tangling and scattering of features
  - dependencies and interactions between features

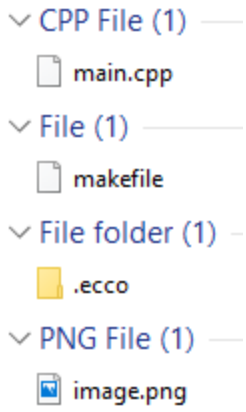
```
1   int main()
2   {
3       #ifdef SOME_FEATURE
4       loadImage("image1.png");
5       #else
6       loadImage("image2.png");
7       #endif
8       return 0;
9   }
10
```

OUR APPROACH: ECCO SYSTEMATIC CLONE-AND-OWN

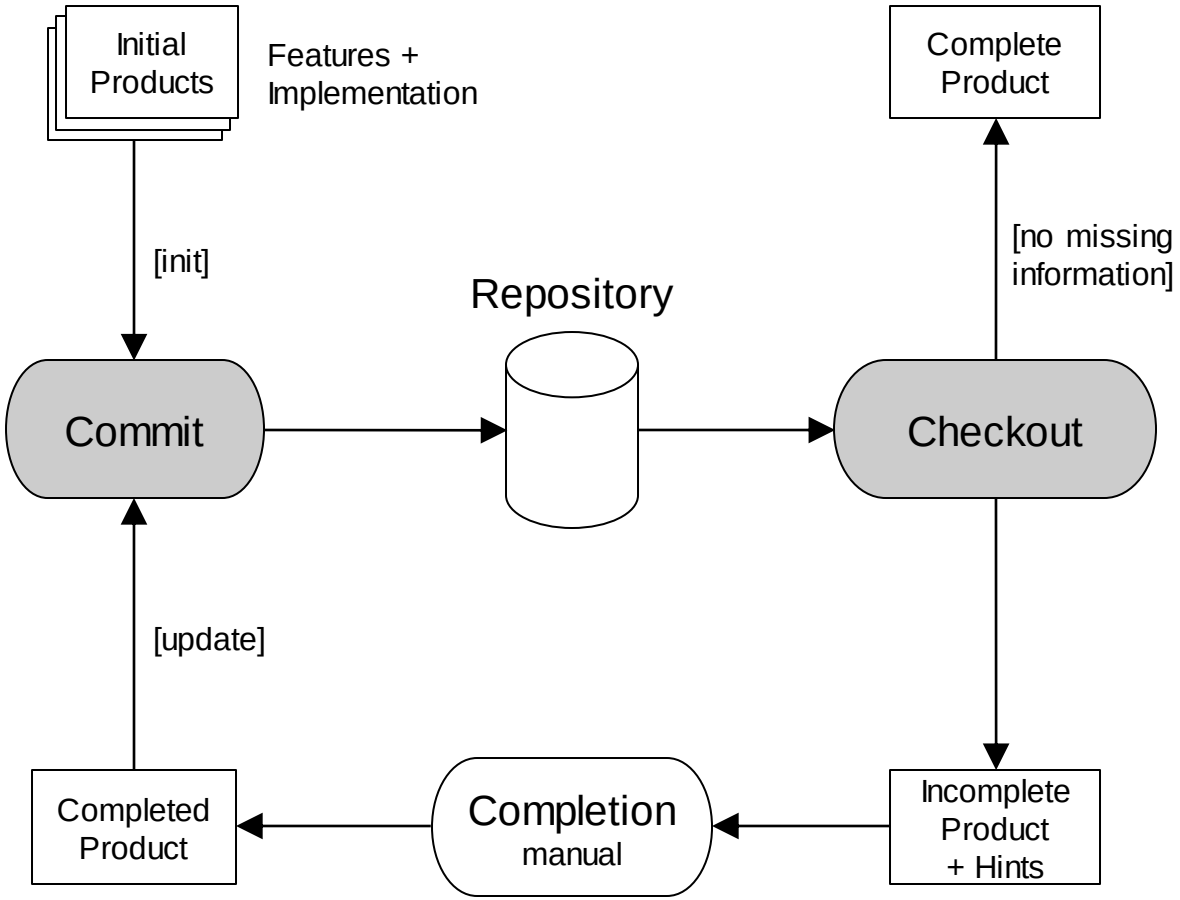
- Version Control System (VCS) as generic variability mechanism
- Instead of retrieving the whole platform which then must be configured (e.g. using make, preprocessors, etc.) only the relevant configuration is checked out
- **Provides a simple view on a complex variable system**
- Features are versioned individually
- Based on concept of traceability

- Operations
  - ☐ `commit <configuration>`
  - ☐ `checkout <configuration>`
  - ☐ `fork <url>`
  - ☐ `push <features>`
  - ☐ `pull <features>`

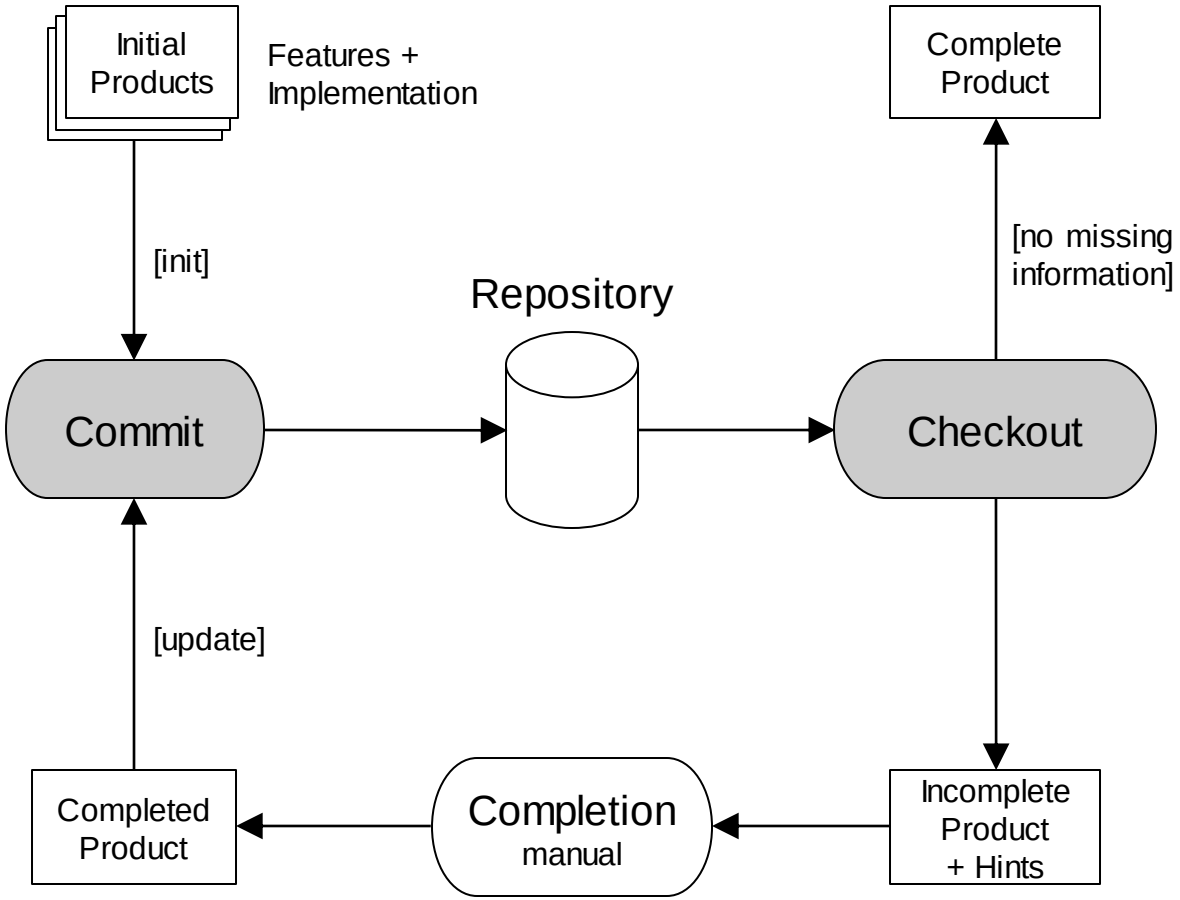
```
1  int main()
2  {
3      loadImage("image.png");
4      return 0;
5  }
6
```



WORKFLOW

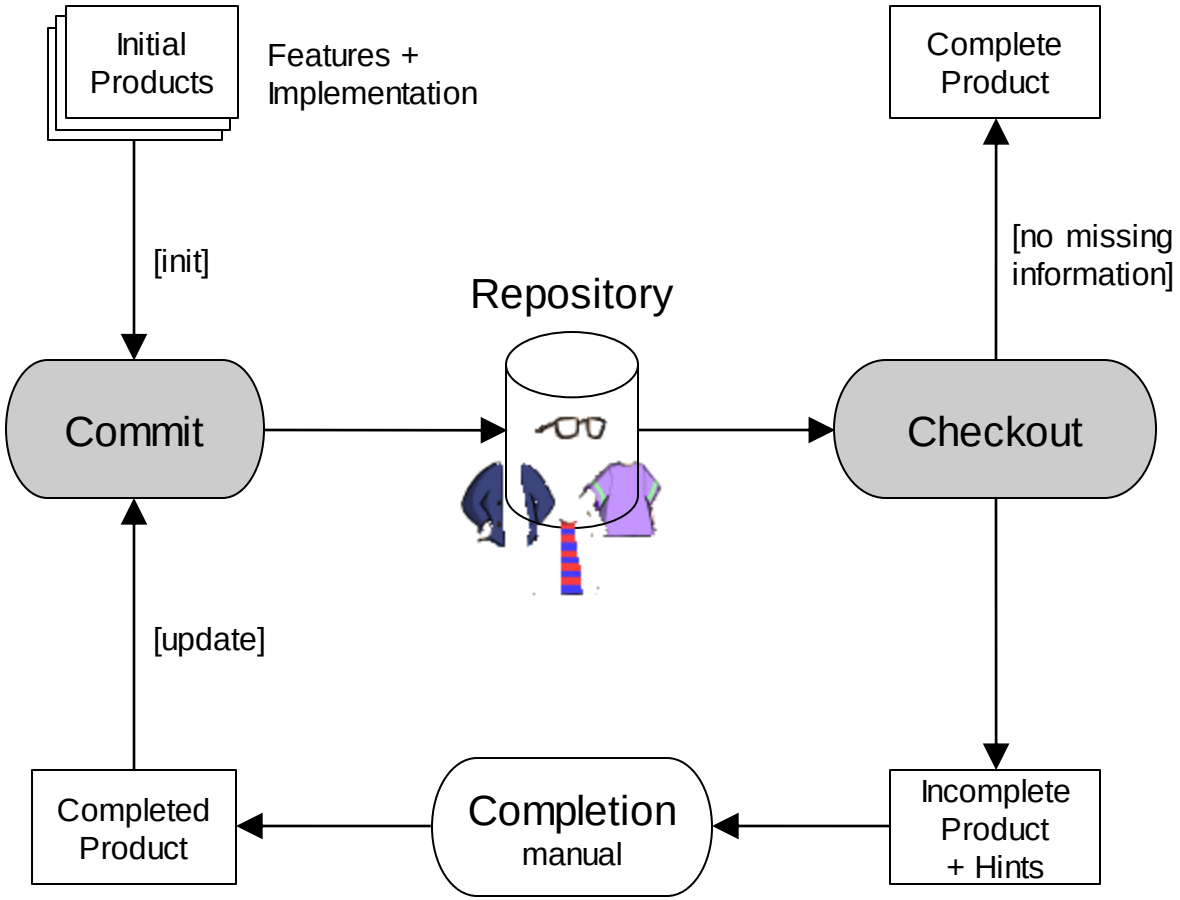

Initial Products
Features + Implementation
Complete Product
[init]
[no missing information]
Repository
Commit
Checkout
[update]
Completed Product
Completion
manual
Incomplete Product + Hints

WORKFLOW

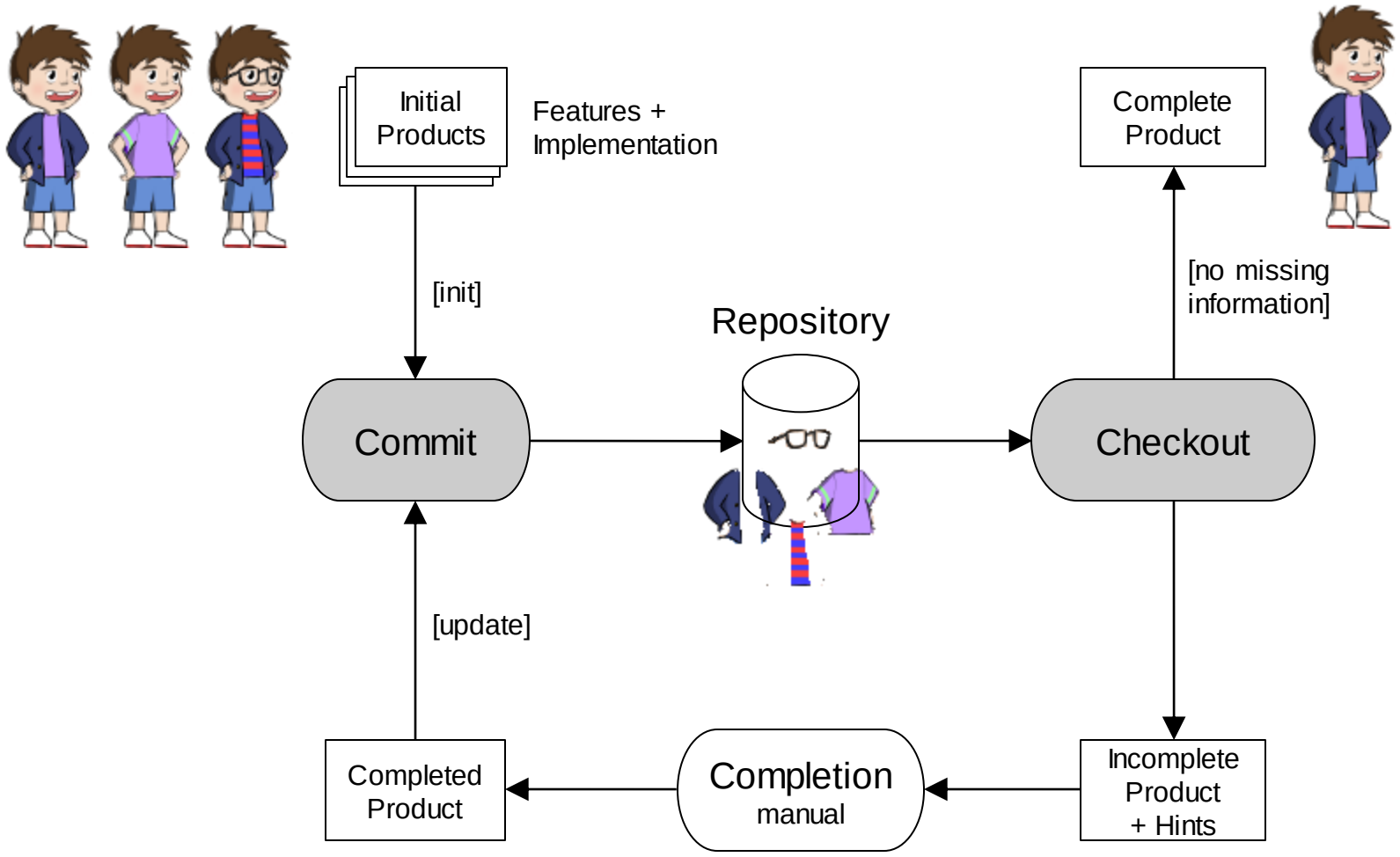



```
ecco commit person, shirt, jacket
ecco commit person, shirt
ecco commit person, jacket, glasses, stripedshirt
```

WORKFLOW

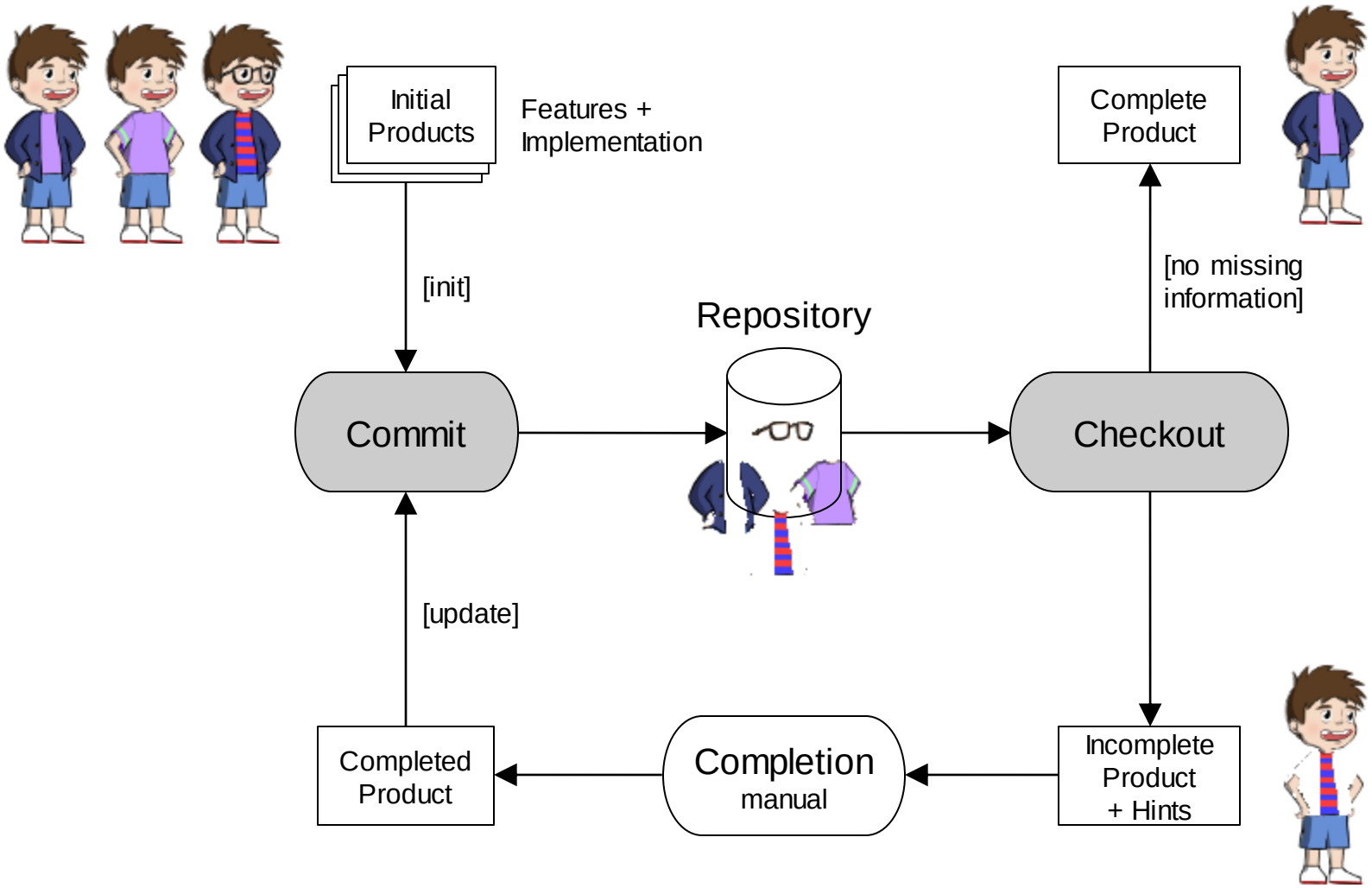

Initial Products
Features + Implementation
Complete Product
[init]
[no missing information]
Repository
Commit
Checkout
[update]
Completed Product
Completion manual
Incomplete Product + Hints

WORKFLOW




```
ecco checkout person, jacket, shirt
```

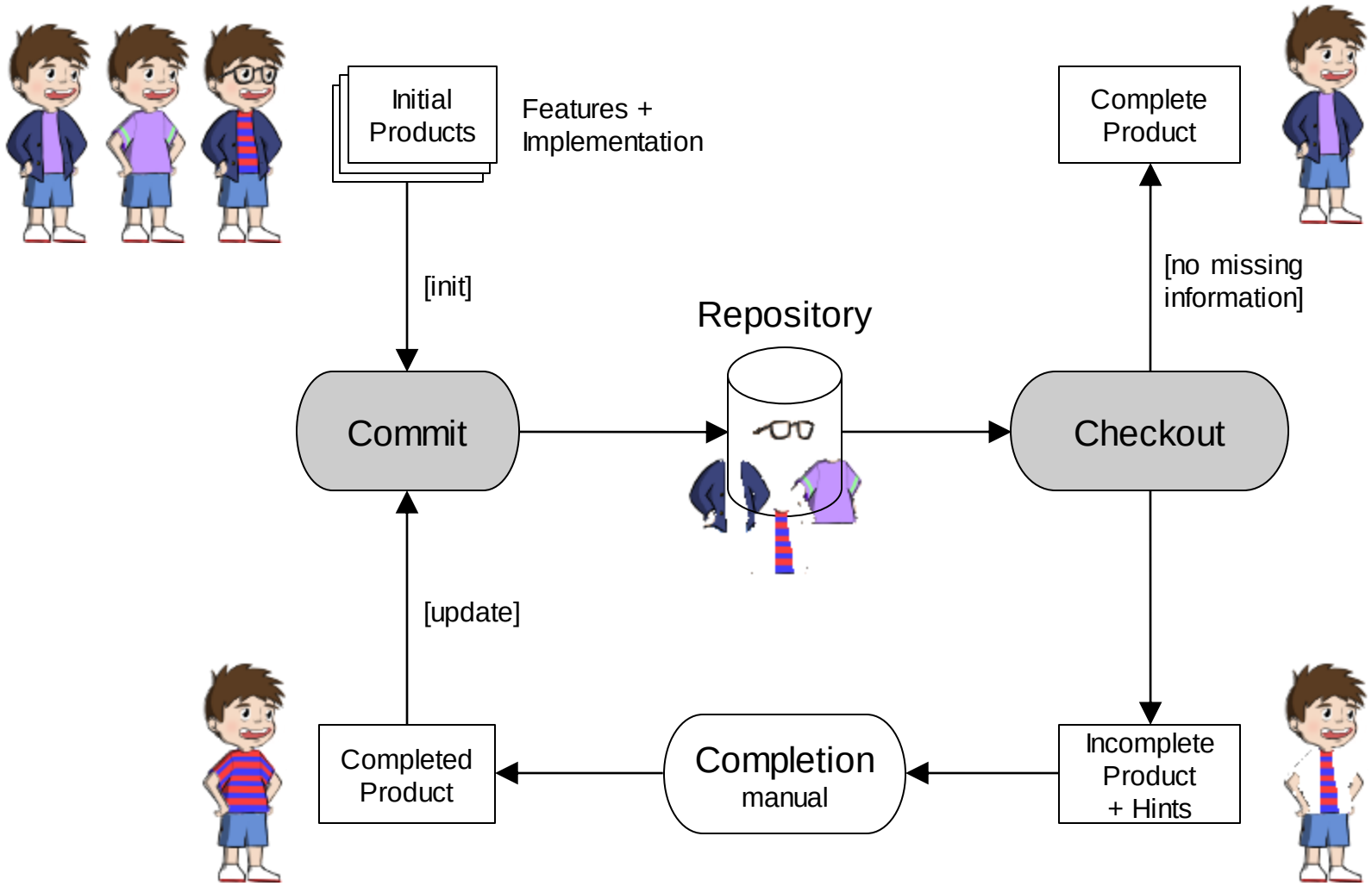
WORKFLOW



`ecco checkout person, stripedshirt`

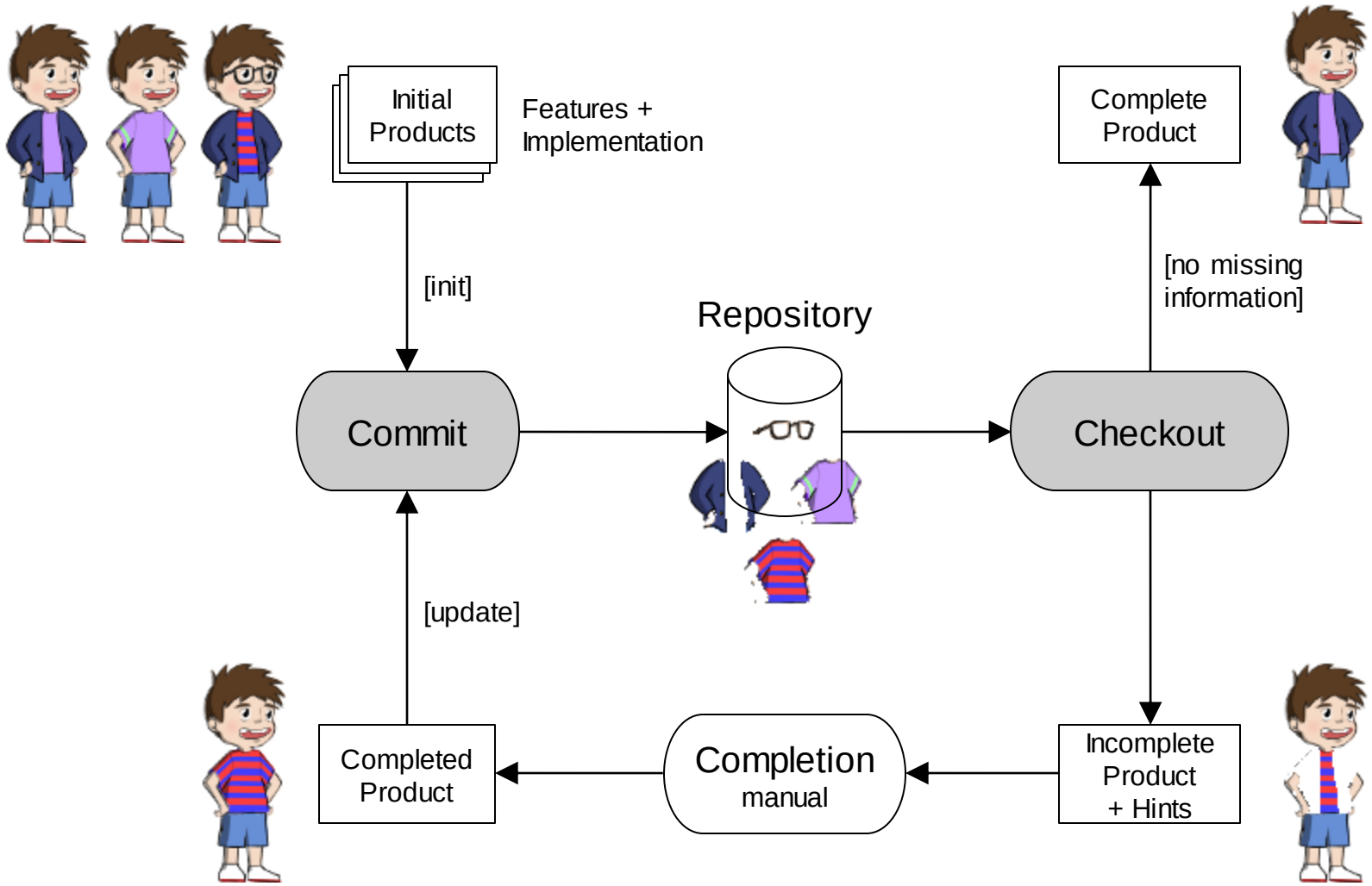
Hint: unknown combination: striped shirt without jacket

WORKFLOW



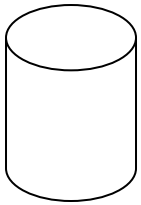
Hint: unknown combination: striped shirt without jacket

WORKFLOW




```
ecco commit person, stripedshirt
```

REPOSITORY



- Collection of automatically computed *traces* between *features* and *artifacts*

$stripedshirt.1 \wedge \neg jacket.1$

$shirt.1 \wedge \neg jacket.1$

$jacket.1$

$stripedshirt.1$

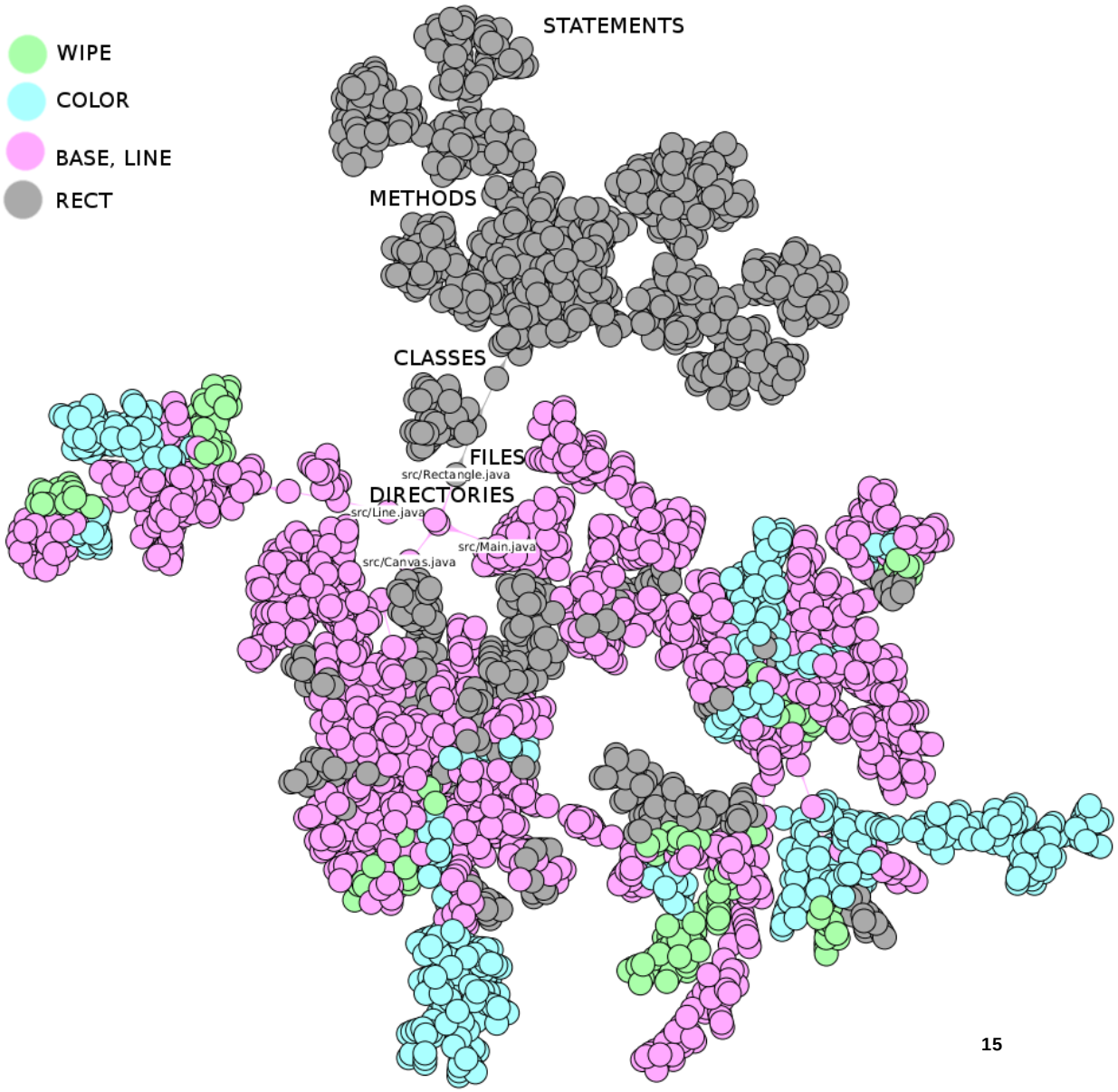
$shirt.1$

$glasses.1$

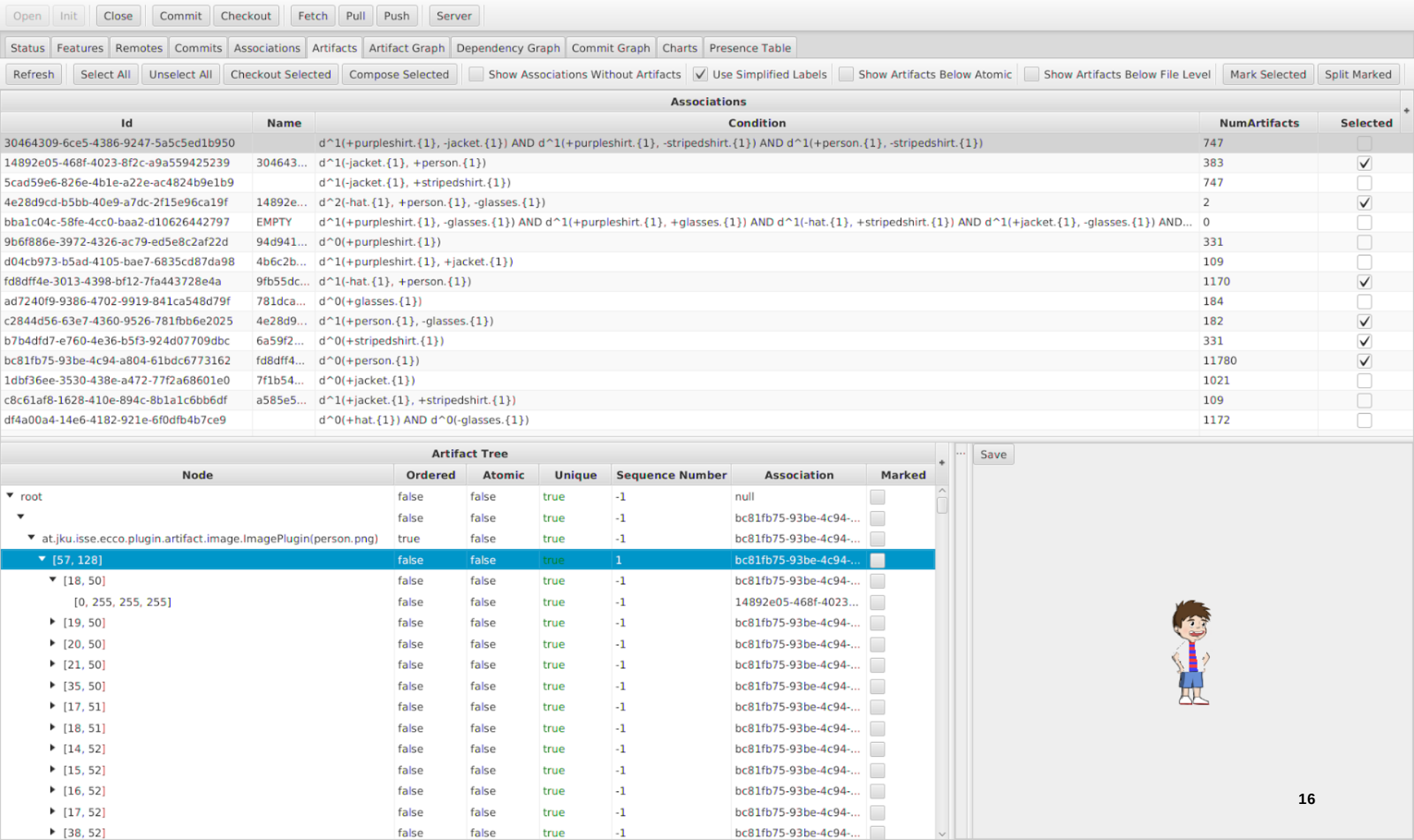
- Versions of features (`ecco commit person, shirt'`)
- Feature versions are part of presence conditions
- Artifacts are organized in a generic tree structure

REPOSITORY

- Tree of artifacts
  - ☐ root in center (coarse)
  - ☐ leaves outside (fine)
- Color for traces



TOOL: GUI


Open
Init
Close
Commit
Checkout
Fetch
Pull
Push
Server
Status
Features
Remotes
Commits
Associations
Artifacts
Artifact Graph
Dependency Graph
Commit Graph
Charts
Presence Table
Refresh
Select All
Unselect All
Checkout Selected
Compose Selected
Show Associations Without Artifacts
Use Simplified Labels
Show Artifacts Below Atomic
Show Artifacts Below File Level
Mark Selected
Split Marked
Associations
Id
Name
Condition
NumArtifacts
Selected
30464309-6ce5-4386-9247-5a5c5ed1b950
d^1(+purpleshirt.{1}, -jacket.{1}) AND d^1(+purpleshirt.{1}, -stripedshirt.{1}) AND d^1(+person.{1}, -stripedshirt.{1})
747
14892e05-468f-4023-8f2c-a9a559425239
304643...
d^1(-jacket.{1}, +person.{1})
383
5cad59e6-826e-4b1e-a22e-ac4824b9e1b9
d^1(-jacket.{1}, +stripedshirt.{1})
747
4e28d9cd-b5bb-40e9-a7dc-2f15e96ca19f
14892e...
d^2(-hat.{1}, +person.{1}, -glasses.{1})
2
bba1c04c-58fe-4cc0-baa2-d10626442797
EMPTY
d^1(+purpleshirt.{1}, -glasses.{1}) AND d^1(+purpleshirt.{1}, +glasses.{1}) AND d^1(-hat.{1}, +stripedshirt.{1}) AND d^1(+jacket.{1}, -glasses.{1}) AND...
0
9b6f886e-3972-4326-ac79-ed5e8c2af22d
94d941...
d^0(+purpleshirt.{1})
331
d04cb973-b5ad-4105-bae7-6835cd87da98
4b6c2b...
d^1(+purpleshirt.{1}, +jacket.{1})
109
fd8dff4e-3013-4398-bf12-7fa443728e4a
9fb55dc...
d^1(-hat.{1}, +person.{1})
1170
ad7240f9-9386-4702-9919-841ca548d79f
781dca...
d^0(+glasses.{1})
184
c2844d56-63e7-4360-9526-781fbb6e2025
4e28d9...
d^1(+person.{1}, -glasses.{1})
182
b7b4dfd7-e760-4e36-b5f3-924d07709dbc
6a59f2...
d^0(+stripedshirt.{1})
331
bc81fb75-93be-4c94-a804-61bdc6773162
fd8dff4...
d^0(+person.{1})
11780
1dbf36ee-3530-438e-a472-77f2a68601e0
7f1b54...
d^0(+jacket.{1})
1021
c8c61af8-1628-410e-894c-8b1a1c6bb6df
a585e5...
d^1(+jacket.{1}, +stripedshirt.{1})
109
df4a00a4-14e6-4182-921e-6f0dfb4b7ce9
d^0(+hat.{1}) AND d^0(-glasses.{1})
1172
Artifact Tree
Node
Ordered
Atomic
Unique
Sequence Number
Association
Marked
root
false
false
true
-1
null
bc81fb75-93be-4c94-...
at.jku.isse.ecco.plugin.artifact.image.ImagePlugin(person.png)
true
[57, 128]
[18, 50]
[0, 255, 255, 255]
14892e05-468f-4023...
[19, 50]
[20, 50]
[21, 50]
[35, 50]
[17, 51]
[18, 51]
[14, 52]
[15, 52]
[16, 52]
[17, 52]
[38, 52]
Save

TOOL: GUI

Open | Init | Close | Commit | Checkout | Fetch | Pull | Push | Server

Status | Features | Remotes | Commits | Associations | Artifacts | Artifact Graph | Dependency Graph | Commit Graph | Charts | Presence Table

Refresh | Select All | Unselect All | Checkout Selected | Compose Selected | ☐ Show Associations Without Artifacts | ☑ Use Simplified Labels | ☐ Show Artifacts Below Atomic | ☐ Show Artifacts Below File Level | Mark Selected | Split Marked

Associations

Id	Name	Condition	NumArtifacts	Selected
30464309-6ce5-4386-9247-5a5c5ed1b950		d^1(+purpleshirt.{1}, -jacket.{1}) AND d^1(+purpleshirt.{1}, -stripedshirt.{1}) AND d^1(+person.{1}, -stripedshirt.{1})	747	☐
14892e05-468f-4023-8f2c-a9a559425239	304643...	d^1(-jacket.{1}, +person.{1})	383	☑
5cad59e6-826e-4b1e-a22e-ac4824b9e1b9		d^1(-jacket.{1}, +stripedshirt.{1})	747	☐
4e28d9cd-b5bb-40e9-a7dc-2f15e96ca19f	14892e...	d^2(-hat.{1}, +person.{1}, -glasses.{1})	2	☑
bba1c04c-58fe-4cc0-baa2-d10626442797	EMPTY	d^1(+purpleshirt.{1}, -glasses.{1}) AND d^1(+purpleshirt.{1}, +glasses.{1}) AND d^1(-hat.{1}, +stripedshirt.{1}) AND d^1(+jacket.{1}, -glasses.{1}) AND...	0	☐
9b6f886e-3972-4326-ac79-ed5e8c2af22d	94d941...	d^0(+purpleshirt.{1})	331	☐
d04cb973-b5ad-4105-bae7-6835cd87da98	4b6c2b...	d^1(+purpleshirt.{1}, +jacket.{1})	109	☐
fd8dff4e-3013-4398-bf12-7fa443728e4a	9fb55dc...	d^1(-hat.{1}, +person.{1})	1170	☑
ad7240f9-9386-4702-9919-841ca548d79f	781dca...	d^0(+glasses.{1})	184	☐
c2844d56-63e7-4360-9526-781fbb6e2025	4e28d9...	d^1(+person.{1}, -glasses.{1})	182	☑
b7b4dfd7-e760-4e36-b5f3-924d07709dbc	6a59f2...	d^0(+stripedshirt.{1})	331	☑
bc81fb75-93be-4c94-a804-61bdc6773162	fd8dff4...	d^0(+person.{1})	11780	☑
1dbf36ee-3530-438e-a472-77f2a68601e0	7f1b54...	d^0(+jacket.{1})	1021	☐
c8c61af8-1628-410e-894c-8b1a1c6bb6df	a585e5...	d^1(+jacket.{1}, +stripedshirt.{1})	109	☐
df4a00a4-14e6-4182-921e-6f0dfb4b7ce9		d^0(+hat.{1}) AND d^0(-glasses.{1})	1172	☐

Traces

Artifact Tree

Node	Ordered	Atomic	Unique	Sequence Number	Association	Marked
▾ root	false	false	true	-1	null	☐
▾	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▾ at.jku.isse.ecco.plugin.artifact.image.ImagePlugin(person.png)	true	false	true	-1	bc81fb75-93be-4c94-...	☐
▾ [57, 128]	false	false	true	1	bc81fb75-93be-4c94-...	☐
▾ [18, 50]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
[0, 255, 255, 255]	false	false	true	-1	14892e05-468f-4023...	☐
▸ [19, 50]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [20, 50]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [21, 50]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [35, 50]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [17, 51]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [18, 51]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [14, 52]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [15, 52]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [16, 52]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [17, 52]	false	false	true	-1	bc81fb75-93be-4c94-...	☐
▸ [38, 52]	false	false	true	-1	bc81fb75-93be-4c94-...	☐

Artifact Tree

Save

Viewer

DISTRIBUTED OPERATIONS

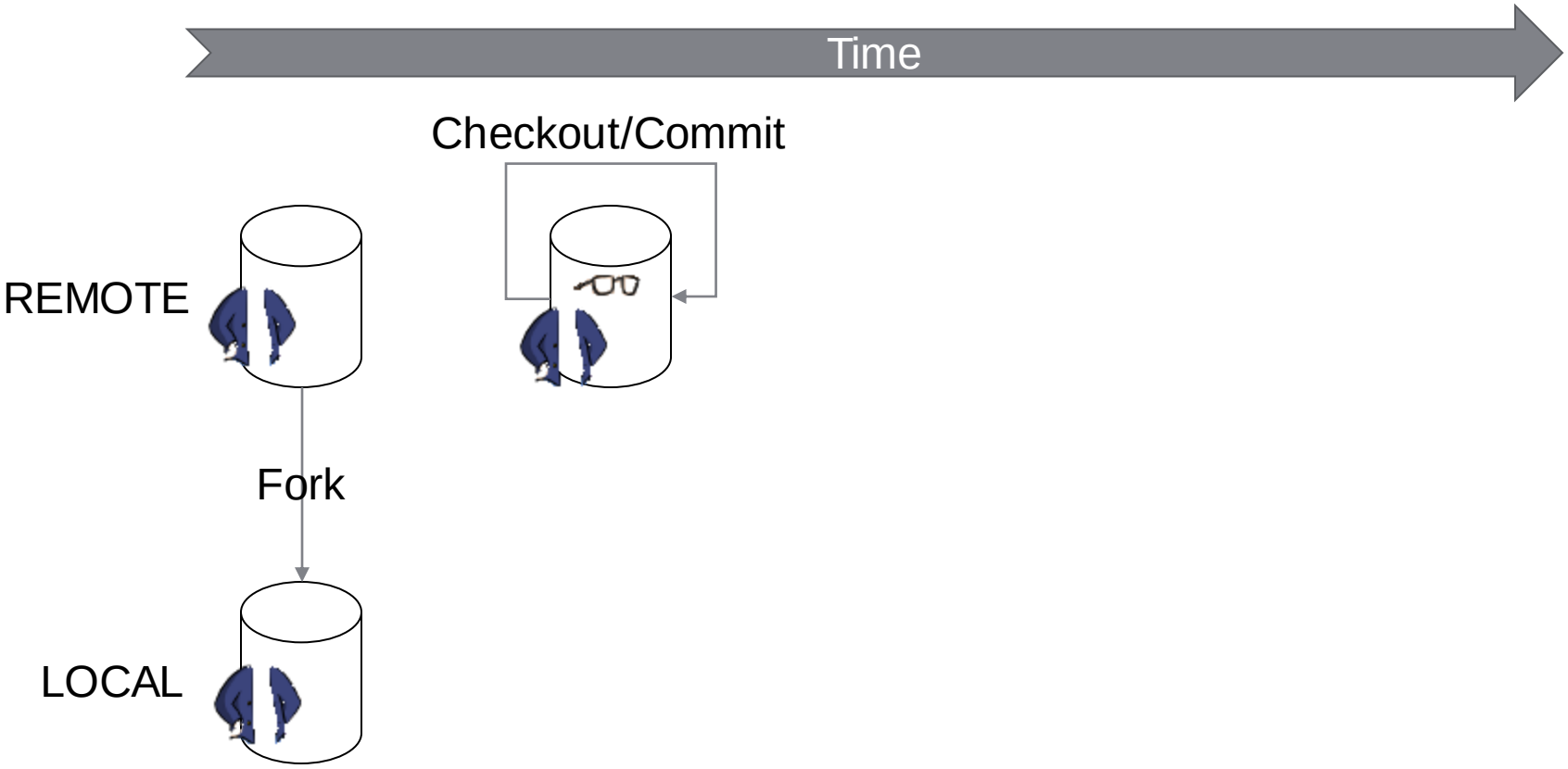
REMOTE

LOCAL

DISTRIBUTED OPERATIONS

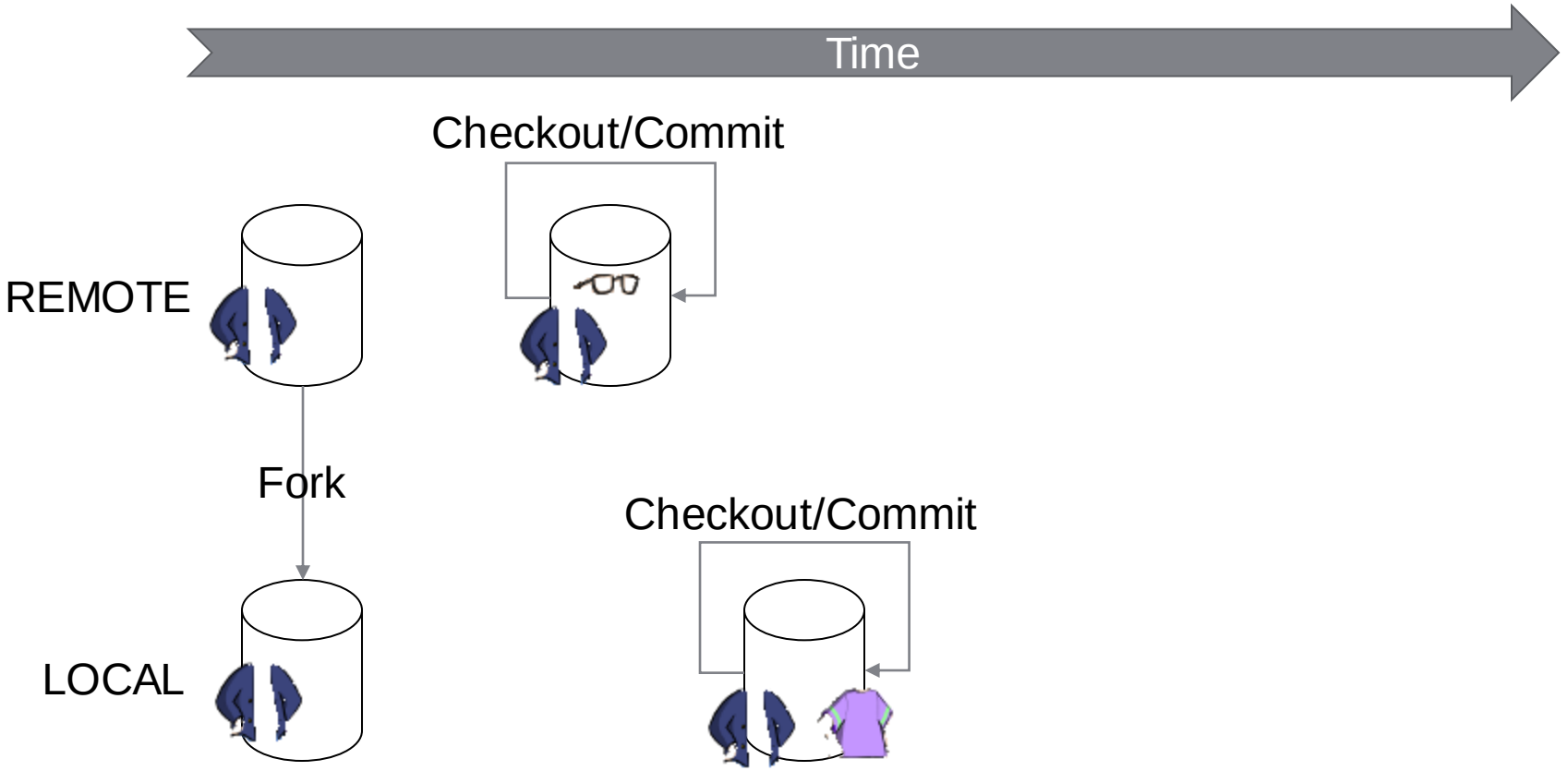
```
ecco fork <url>
```

DISTRIBUTED OPERATIONS



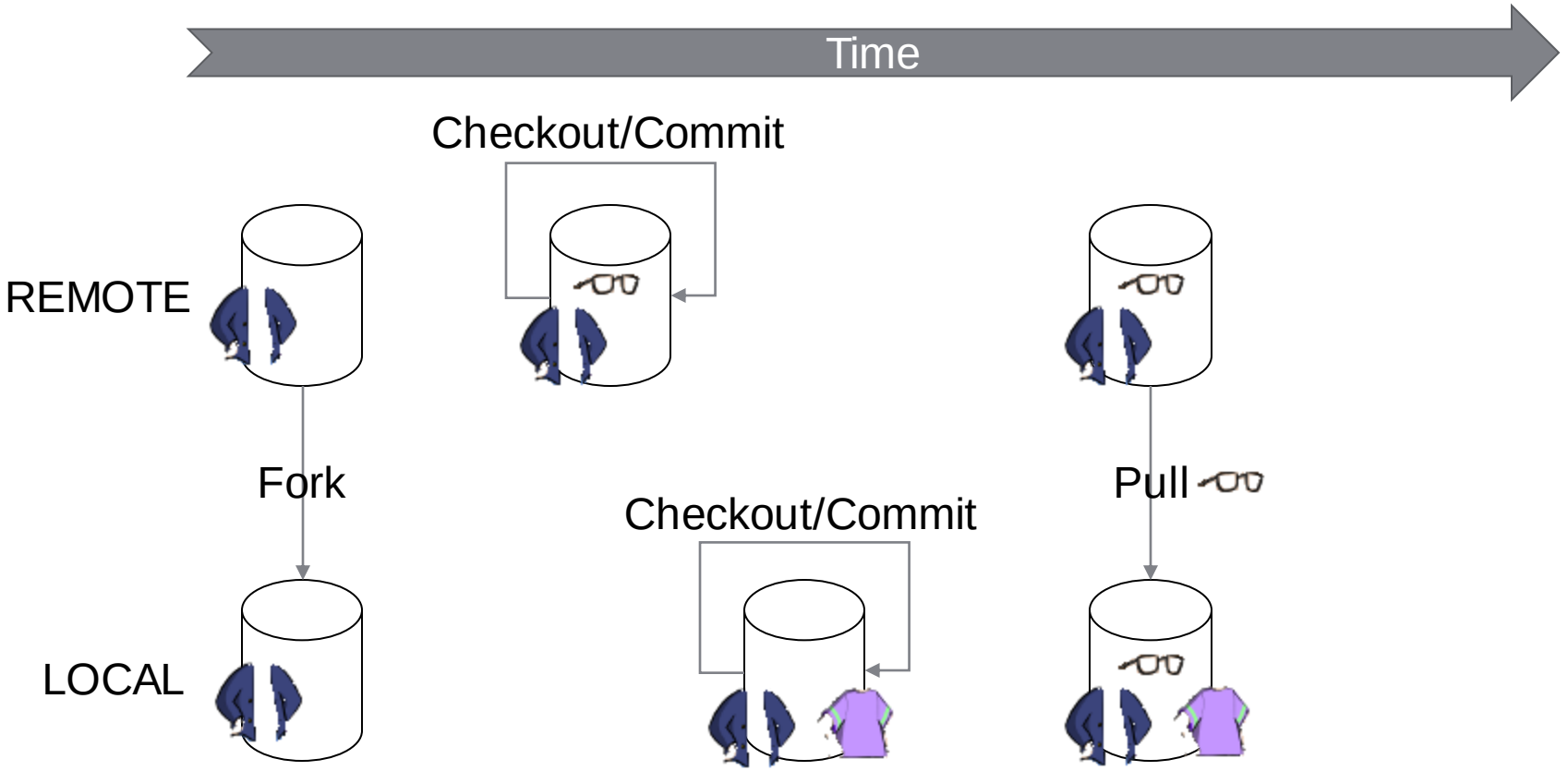

```
ecco checkout person, jacket, …
ecco commit person, jacket, glasses, …
```

DISTRIBUTED OPERATIONS



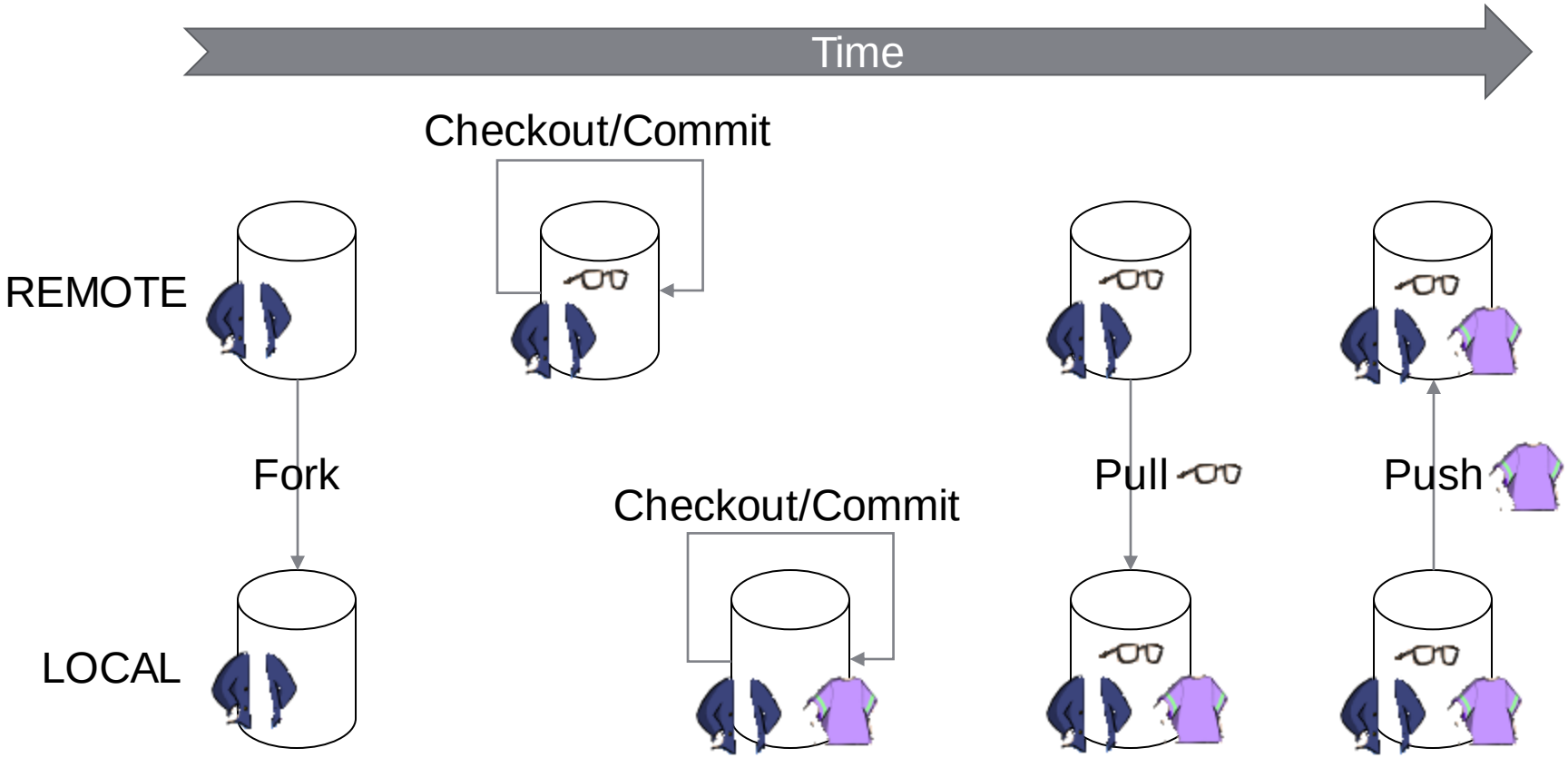

```
ecco checkout person, jacket, …
ecco commit person, jacket, shirt, …
```

DISTRIBUTED OPERATIONS




```
ecco pull glasses
```

DISTRIBUTED OPERATIONS




```
ecco push shirt
```

BENEFITS

- Combine advantages of ad hoc and structured approaches without their disadvantages
  - changes are performed on concrete variants
  - automated reuse and easy maintenance
  - low upfront costs and easy to extend and modify
- Provide a generic variability mechanism
  - different types of implementation artifacts
  - at any level of granularity
- Transparent to other development tools (e.g. no special IDE needed)
- Knowledge of what features exist, how they interact, and where they are implemented
- Flexibility and automation when creating new variants
- Track changes to features and choose what variants to affect
- Enables distributed, feature-oriented development

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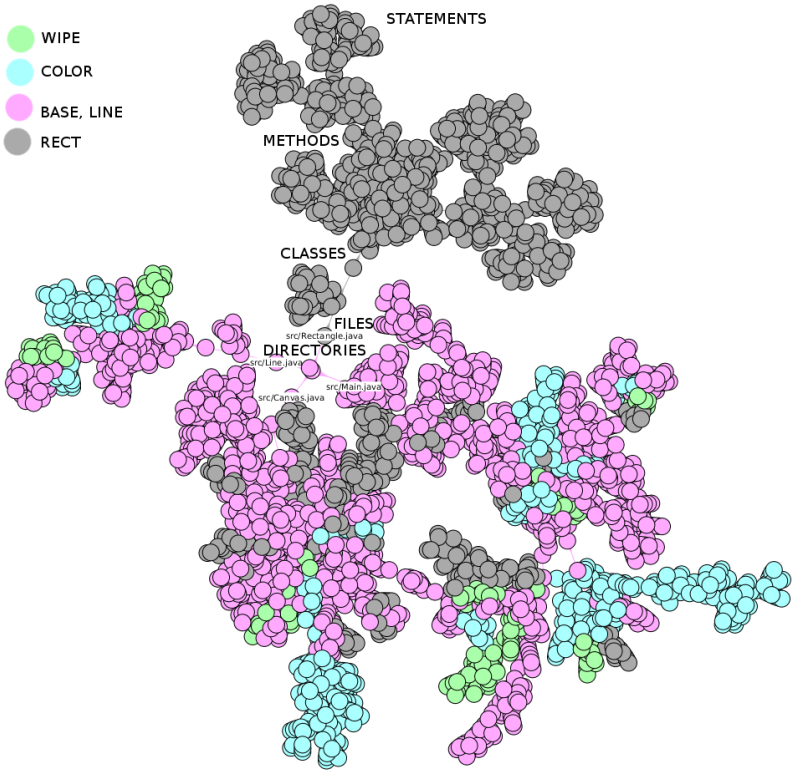
UNIVERSITY LINZ

THANK YOU!



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