Laracon EU 2025

Internals of Composer

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Private Packagist
https://packagist.com

Why is Composer 2 so much faster?

Why is Composer 2 so much faster?

- Benchmarks
  - install 30% to 50% faster
  - update 30% to 90% faster & drop in memory usage of 70% to 98%

- Easy answers
  - parallel downloads, making use of HTTP/2 features
  - parallel archive extraction
  - more efficient metadata format

  - doesn’t really explain improvements for update

https://blog.packagist.com/composer-2-0-is-now-available/
https://susi.dev/composer2-perf
https://developers.ibexa.co/blog/benchmarks-of-composer-2.0-vs-1.10
https://metadrop.net/es/articulos/drupal-composer-2

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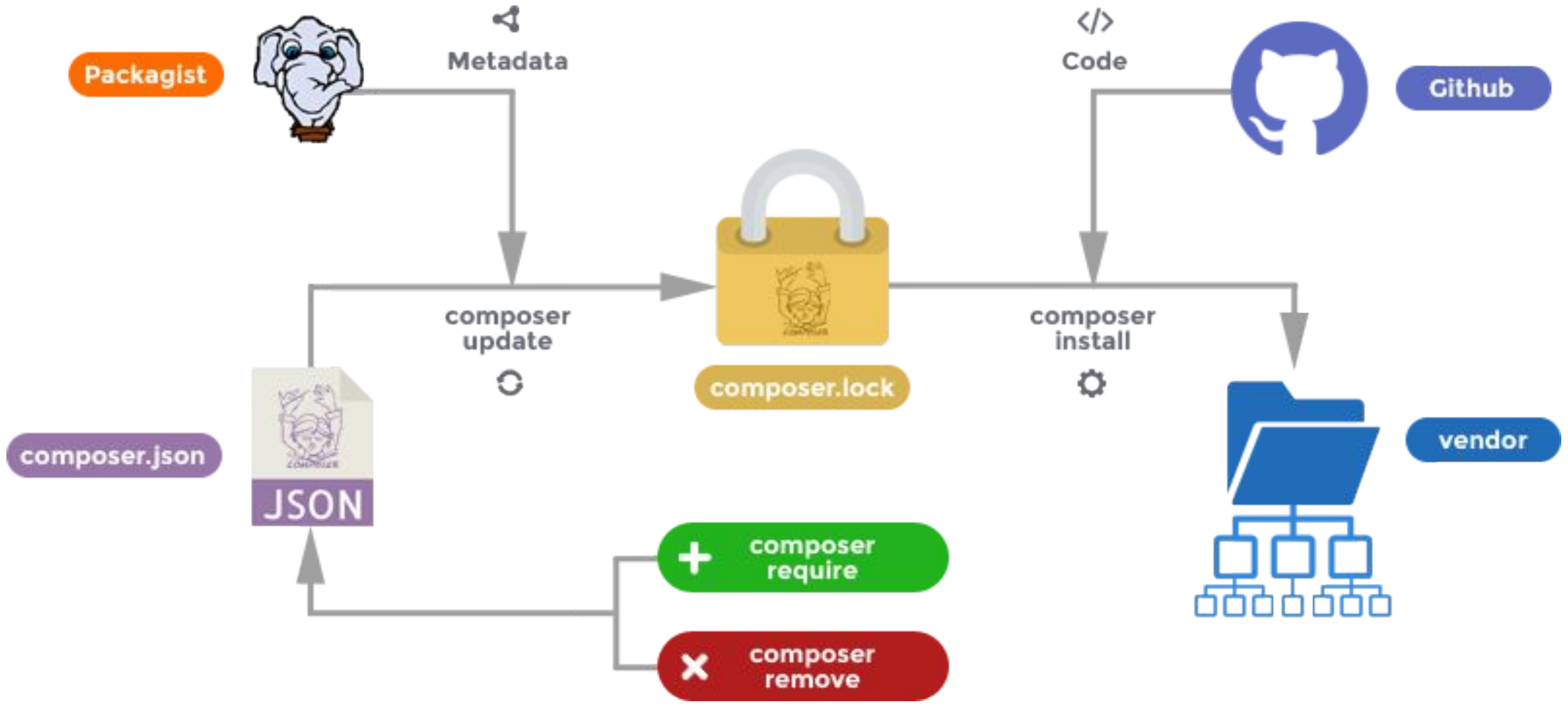
Separating update & install - Declaring state over manipulating state



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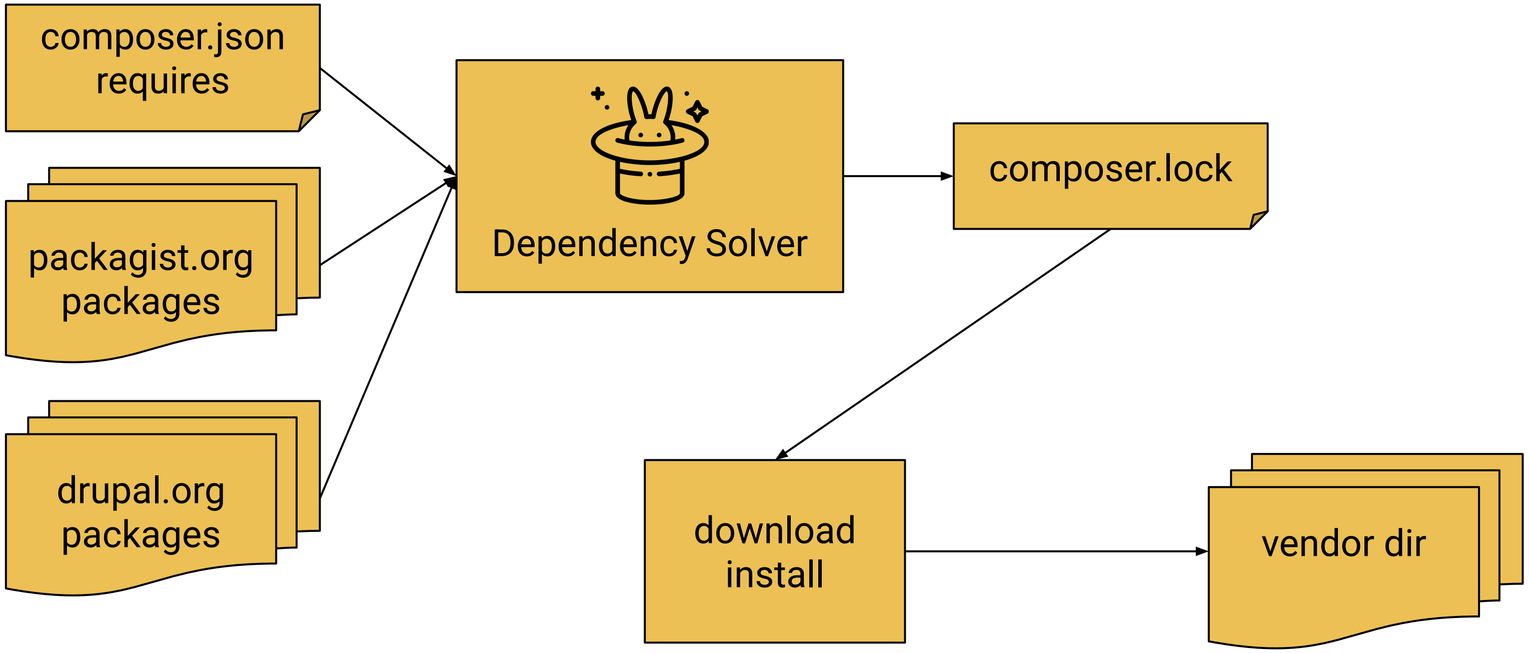
Separating update & install

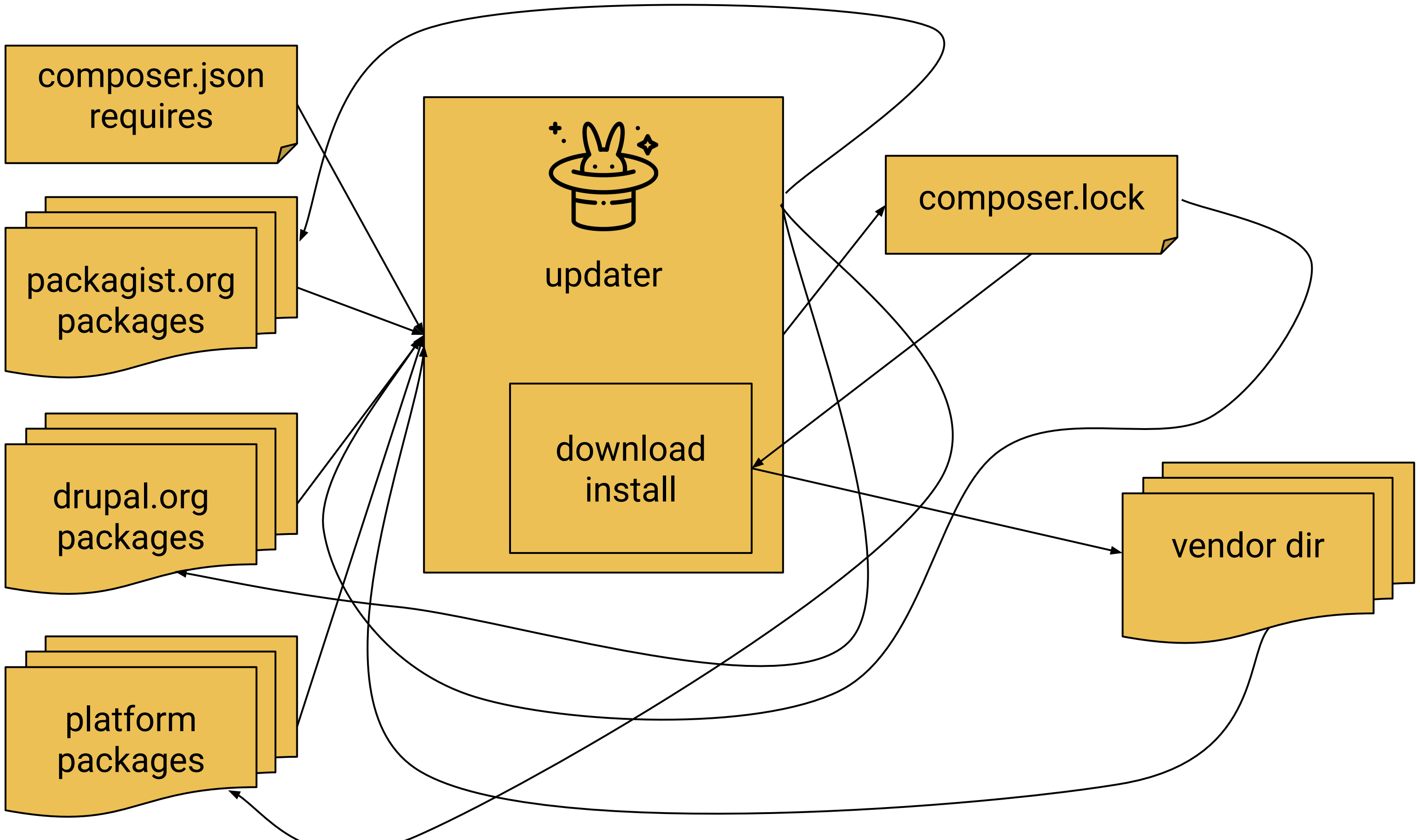
vendor		
symfony/http-foundation:	7.2.0	previous local upgrade attempt
composer.lock		
symfony/http-foundation:	6.4.16	old production state
composer.json		
symfony/http-foundation:	7.1.*	limited upgrade for now, because of 6.3 issues

```
naderman@saumur:~/projects/composer/test/symfony-http-foundation$ composer update
Loading composer repositories with package information
Updating dependencies
Lock file operations: 0 installs, 1 update, 0 removals
 - Upgrading symfony/http-foundation (v6.4.16 => v7.1.9)
Writing lock file
Installing dependencies from lock file (including require-dev)
Package operations: 3 installs, 1 update, 1 removal
 - Removing symfony/deprecation-contracts (v3.5.1)
 - Downgrading symfony/http-foundation (v7.2.0 => v7.1.9): Extracting archive
Generating autoload files
6 packages you are using are looking for funding.
Use the `composer fund` command to find out more!
```

composer update: The idea



composer update: Reality in Composer 1



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composer update: Reality in Composer 1 - aka some terrible ideas

- Idea: Solver only loads what it needs when it gets to that point
    - Solution: **Lazy load packages** while creating memory representation in solver
    - Problems
        - Solver just waits for same info at a later point
        - Impossible to reduce set of packages before generating dependencies
        - Parallelized network access becomes hard to manage

- Idea: Avoid downloading metadata and packages unnecessarily and protect from loss of packages
    - Solution: **use vendor/ and composer.lock metadata in solver**
    - Problems
        - Duplicate metadata
        - Unclear which “version” to use / when to update metadata
        - Confusing results where packages that no longer exist don’t get removed
        - Inconsistent behavior depending on local state

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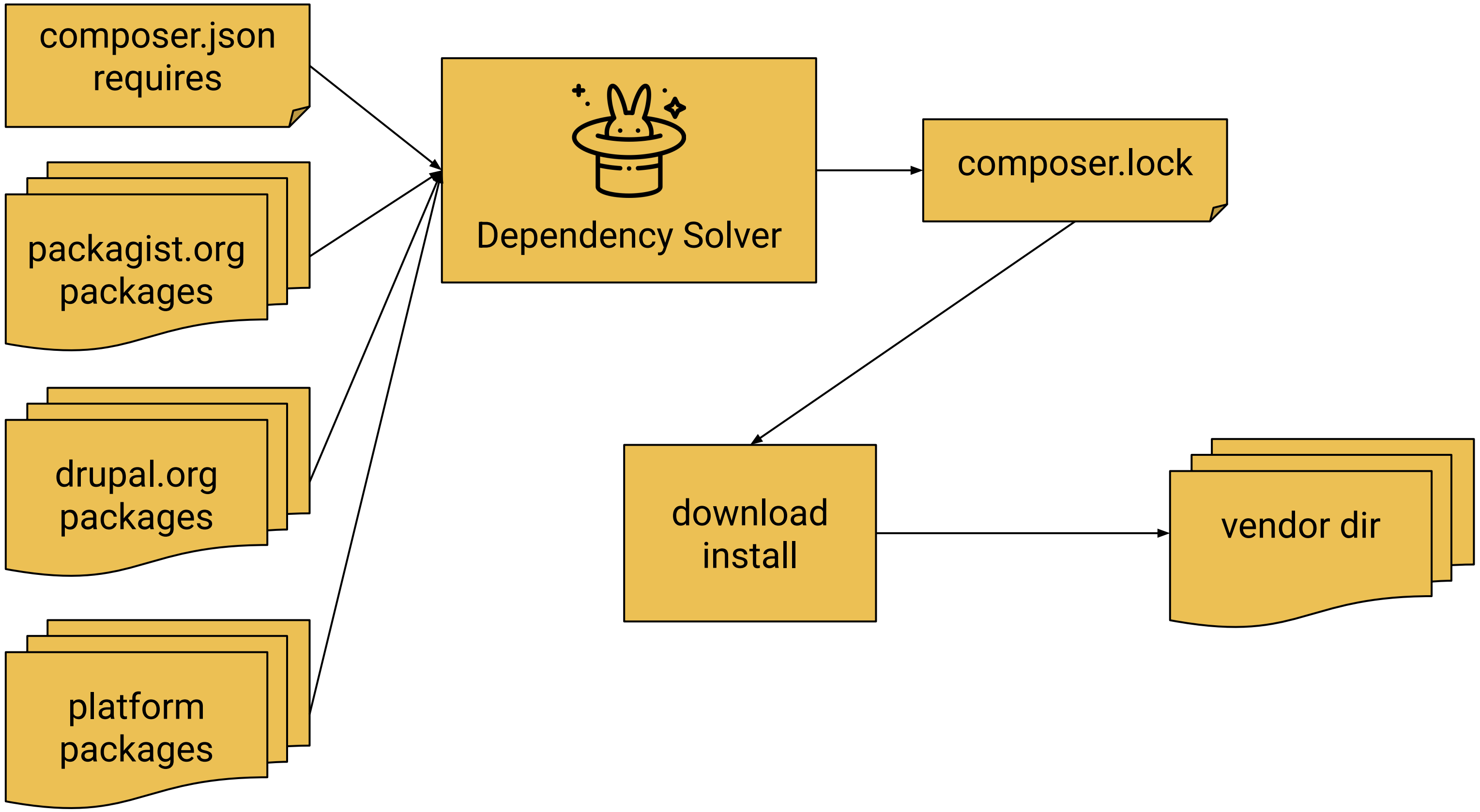
composer update: The idea



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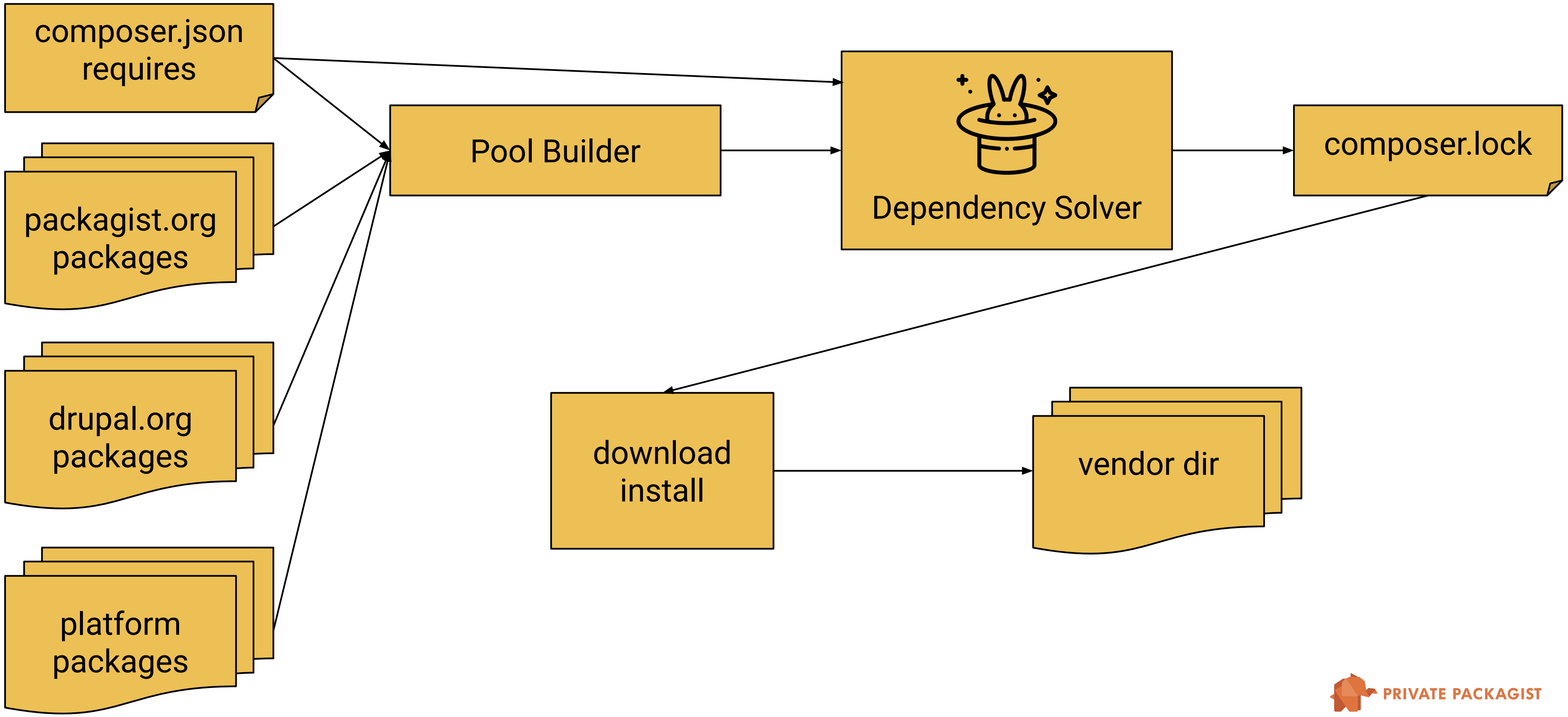
composer update: Reality in Composer 2



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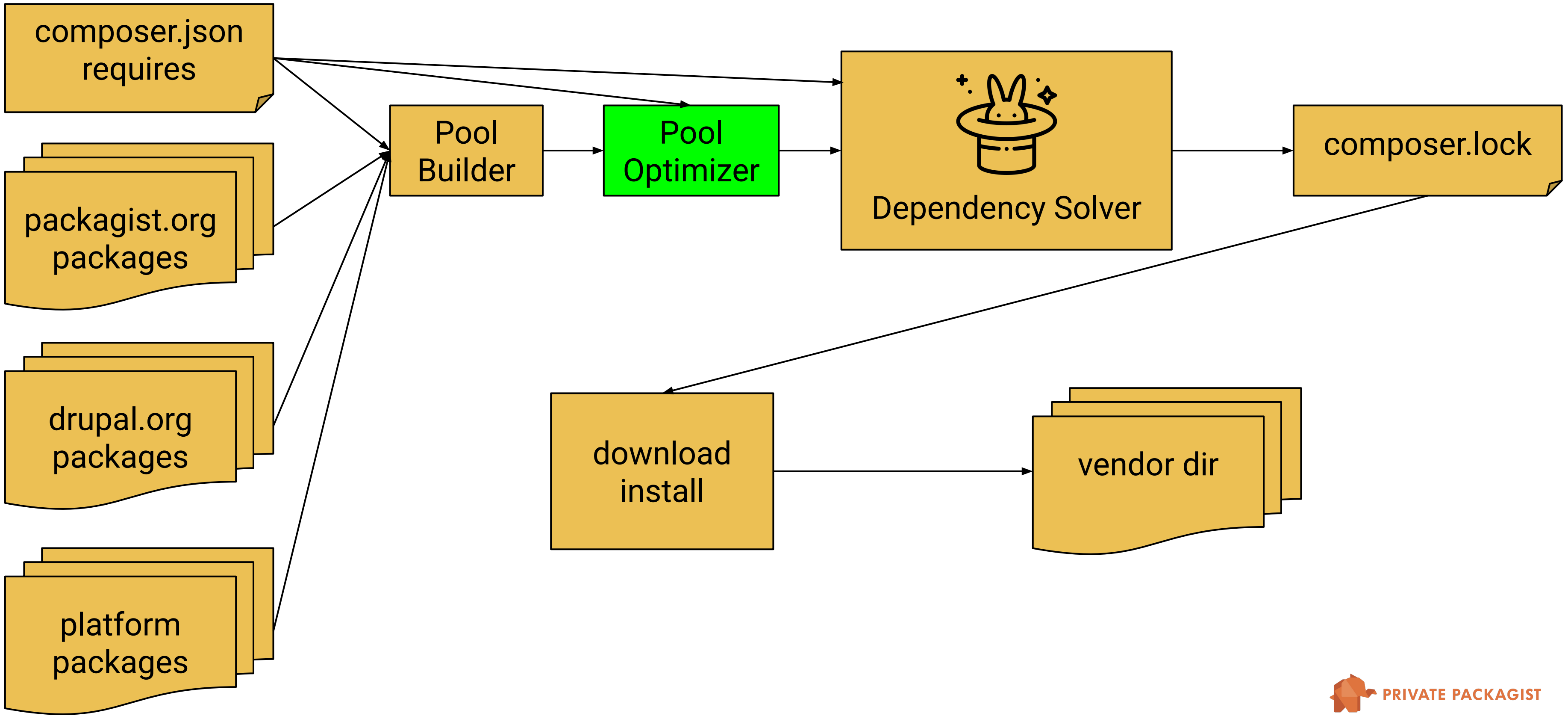
composer update: Reality in Composer 2.2



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composer update: Reality in Composer 2.2

- **Pool**
  - Simple array of all package versions to be passed to the Dependency Solver

- **Pool Builder** collects package metadata from all sources/repositories
  - Takes root composer.json requires into account
  - Avoids loading metadata that is definitely not installable
  - Tries to limit how many versions of a package get loaded by tracking constraints

- **Pool Optimizer**
  - identifies versions with identical constraints and reduces them into one
  - Shout out to Jason Woods / driskell for two additions based on Drupal projects
    - Filters impossible packages out https://github.com/composer/composer/pull/9620/files
    - Do not load replaced targets https://github.com/composer/composer/pull/11449
  - more future improvements possible!

What’s in the Dependency Solver?

And why does reducing loaded package versions matter so much?

Boolean Algebra

- Notation
  - OR: $\vee$
  - AND: $\wedge$
  - NOT: $\neg$
- Laws
  - Associativity: $A \vee (B \vee C) = (A \vee B) \vee C$
  - Commutativity: $A \vee B = B \vee A$
  - Distributivity: $A \vee (B \wedge C) = (A \vee B) \wedge (A \vee C)$
  - Absorption: $A \vee (A \wedge B) = A$
  - Complementation 2: $A \vee \neg A = \text{TRUE}$
  - etc.

Conjunctive Normal Form

- $(A \lor B) \land (\neg B \lor C \lor \neg D) \land (D \lor \neg E)$
- $(A \lor B)$ is a clause
- A, B, ¬B, C, D, ¬D, E are literals
- A, B, C, D are atoms

Every propositional formula can be converted into an equivalent formula that is in CNF. This transformation is based on rules about logical equivalences: the double negative law, De Morgan's laws, and the distributive law.

What’s in the Dependency Solver?

- SAT Solver
  - boolean SATisfiability
  - Is there a set of values for a boolean formula that results in its evaluation to true
  - $(A \land B)$ is satisfiable with A=TRUE and B=TRUE.
  - $(A \land B \land \neg A)$ is not satisfiable because A cannot be both TRUE and FALSE.
- Why a SAT Solver?
  - Port from libzypp / zypper in SUSE back in 2011
  - EDOS project https://www.mancoosi.org/edos/ - Package Installation is NP-Complete
    - https://www.mancoosi.org/edos/algorithmic/#toc15 (For the really interested here you can see someone encode any 3SAT problem as a debian or RPM package installation)

Dependencies as a SAT Problem

- Each version of a package is a literal
  - Package A v1.0.0 should be present: **A-1.0.0**
  - Package A v1.0.0 should not be present: **¬A-1.0.0**

- A-1.0.0 requires B-1.0.0: **(¬A-1.0.0 ∨ B-1.0.0)**
- A-1.0.0 conflicts with B-1.0.0: **(¬A-1.0.0 ∨ ¬B-1.0.0)**
- C-1.0.0 and D-1.0.0 provide B-1.0 and A-1.0 requires B-1.0
  (¬A-1.0.0 ∨ C-1.0.0 ∨ D-1.0.0)
- C-1.0.0 replaces B-1.0 and A-1.0 requires B-1.0
  (¬C-1.0.0 ∨ ¬B-1.0.0) ∧ (¬A-1.0.0 ∨ B-1.0.0 ∨ C-1.0.0)

Fewer packages/versions to analyze? => fewer literals, fewer clauses, less memory

Dependencies as a SAT Problem: Example

project requires A *, A 1.0.0 requires B * and C *, B requires C *

1.		**(A-1.0.0)**	∧ (¬A-1.0.0 ∨ B-1.0.0)	∧ (¬B-1.0.0 ∨ C-1.0.0)	∧ (¬A-1.0.0 ∨ C-1.0.0)
2.	**A-1.0.0=true**	**true**	∧ (**false** ∨ B-1.0.0)	∧ (¬B-1.0.0 ∨ C-1.0.0)	∧ (**false** ∨ C-1.0.0)
3.		true	∧ **(B-1.0.0)**	∧ (¬B-1.0.0 ∨ C-1.0.0)	∧ **(C-1.0.0)**
4.	**B-1.0.0=true**	true	∧ **true**	∧ (**false** ∨ C-1.0.0)	∧ (C-1.0.0)
5.		true	∧ **true**	∧ **(C-1.0.0)**	∧ **(C-1.0.0)**
6.	**C-1.0.0=true**	true	∧ true	∧ **true**	∧ **true**

Solved: Install A 1.0.0, B 1.0.0, C 1.0.0

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Dependencies as a SAT Problem: Example

project requires A *, A 1.0.0 requires B * and C *, B **conflicts** with C *

1.		**(A-1.0.0)**	∧ (¬A-1.0.0 ∨ B-1.0.0)	∧ (¬B-1.0.0 ∨ ¬C-1.0.0)	∧ (¬A-1.0.0 ∨ C-1.0.0)
2.	**A-1.0.0=true**	**true**	∧ (**false** ∨ B-1.0.0)	∧ (¬B-1.0.0 ∨ ¬C-1.0.0)	∧ (**false** ∨ C-1.0.0)
3.		true	∧ **(B-1.0.0)**	∧ (¬B-1.0.0 ∨ ¬C-1.0.0)	∧ **(C-1.0.0)**
4.	**B-1.0.0=true**	true	∧ **true**	∧ (**false** ∨ ¬C-1.0.0)	∧ (C-1.0.0)
5.		true	∧ **true**	∧ **(¬C-1.0.0)**	∧ **(C-1.0.0)**
6.	**C-1.0.0=false**	true	∧ true	∧ **true**	∧ **false**

Conflict! A requires C, but B conflicts with C.

Free Choices / Policy

- Policy determines precedence of solution attempts for free choices
  - By default always try the highest version number first
  - Can be altered with flags like --prefer-lowest (reverse)

Dependencies as a SAT Problem: Example with free choice

project requires A *, A 1.0.0 requires B *, B 2.0.0 requires C *

1.		**(A-1.0.0)**	∧ (¬A-1.0.0 ∨ B-1.0.0 ∨ B-2.0.0)	∧ (¬B-2.0.0 ∨ C-1.0.0)	
2.	**A-1.0.0=true**	**true**	∧ (**false** ∨ B-1.0.0 ∨ B-2.0.0)	∧ (¬B-2.0.0 ∨ C-1.0.0)	
3.		true	∧ **(B-1.0.0 ∨ B-2.0.0)**	∧ (¬B-2.0.0 ∨ C-1.0.0)	
4.	**B-2.0.0=true**	true	∧ **(B-1.0.0∨ true)**	∧ (**false** ∨ C-1.0.0)	**[Policy]**
5.		true	∧ **true**	∧ **(C-1.0.0)**	
6.	**C-1.0.0=true**	true	∧ true	∧ **true**	

Solved: Install A 1.0.0, **B 2.0.0**, C 1.0.0

Implementation

- Each package version object gets an integer id
- \Composer\DependencyResolver\Rule contains an array of literals
  - absolute value is the id, sign is used for negation
- \Composer\DependencyResolver\Solver::solve()
  - generates rules based on package pool and policy
  - finds solution with runSat()
  - returns new lock file state
- \Composer\DependencyResolver\DefaultPolicy
  - implements free choice decisions
  - handles options like --prefer-lowest or --prefer-stable

Representing dependencies/conflicts more efficiently

Regular requirements and conflicts

```
foo/bar 1.0 requires baz/qux ^2.0          (¬foo/bar 1.0 ∨ baz/qux 2.0.0 ∨ baz/qux 2.0.1 ∨ baz/qux 2.1.0)
foo/bar 1.0 conflicts with baz/qux ^2.0    (¬foo/bar 1.0 ∨ ¬baz/qux 2.0.0) ∧ (¬foo/bar 1.0 ∨ ¬baz/qux 2.0.1) ∧
                                           (¬foo/bar 1.0 ∨ ¬baz/qux 2.1.0)
```

You can only install one version of a package

=> Composer automatically generates a conflict for each pair of versions

```
foo/bar 1.0, 1.1, 1.2                      ( ¬foo/bar 1.0 ∨ ¬foo/bar 1.1) ∧ (¬foo/bar 1.0 ∨ ¬foo/bar 1.2) ∧
                                           ( ¬foo/bar 1.1 ∨ ¬foo/bar 1.2)
```

Extreme Growth $\binom{n}{2} = \frac{n!}{2(n-2)!}$

	3 versions	6 versions	100 versions	***Symfony*** 500 versions	1000 versions
Composer 1	3 rules	15 rules	4,950 rules	**124,750** rules	**499,500** rules
Composer 2	1 rule	1 rule	1 rule	1 rule	1 rule

Composer 2.0 uses a special single multi conflict rule representation for all of these rules

```
foo/bar 1.0, 1.1, 1.2                      oneof(foo/bar 1.0, foo/bar 1.1,foo/bar 1.2)
```

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Partial Updates

```
{   “name”: “zebra/zebra”,
    “require”: {
        “horse/horse”: “^1.0” }}

{   “name”: “giraffe/giraffe”,
    “require”: {
        “duck/duck”: “^1.0” }}
```

Partial Updates

```
{   “name”: “horse/horse”,
    “require”: {
        “giraffe/giraffe”: “^1.0” }}

{   “name”: “duck/duck”,
    “require”: {}}
```

Partial Updates

```
{
    “name”: “my-project”,
    “require”: {
        “zebra/zebra”: “^1.0”,
        “giraffe/giraffe”: “^1.0”
    }
}
```

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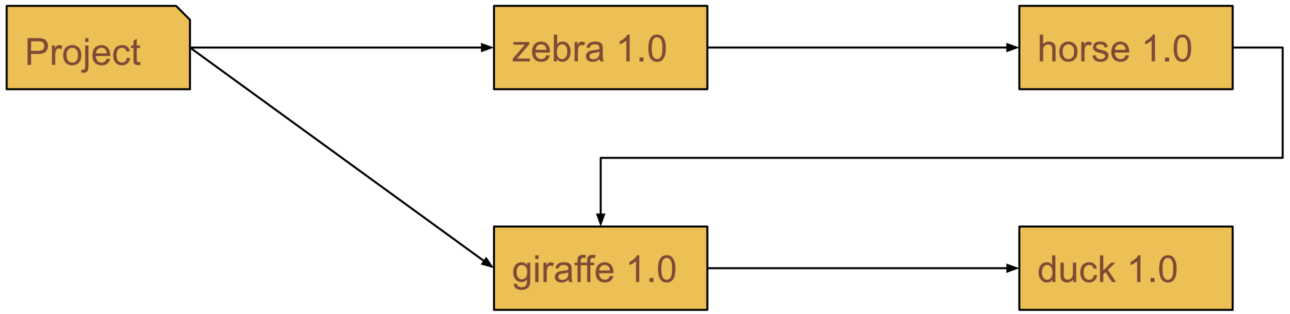
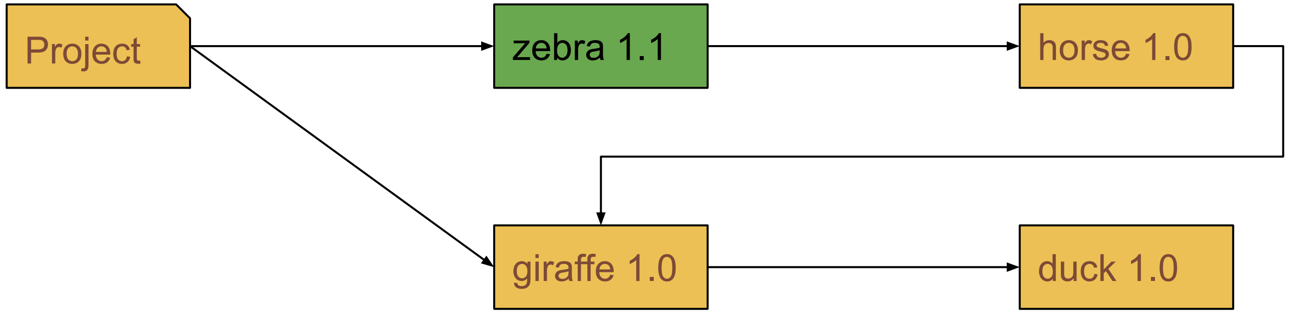
Partial Updates



`Now each package releases 1.1`

Partial Updates



```
$ composer update --dry-run zebra/zebra
    Updating zebra/zebra (1.0 -> 1.1)
```

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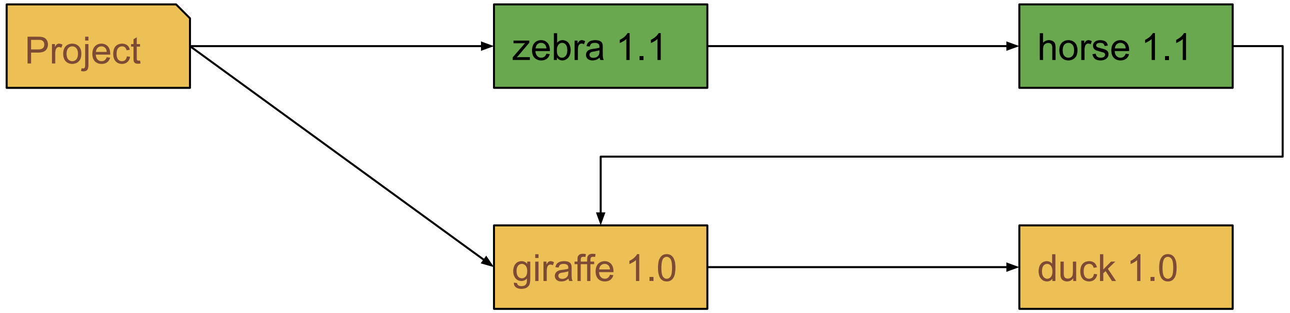
Partial Updates



```
$ composer update --dry-run zebra/zebra --with-dependencies
   Updating horse/horse (1.0 -> 1.1)
   Updating zebra/zebra (1.0 -> 1.1)
```

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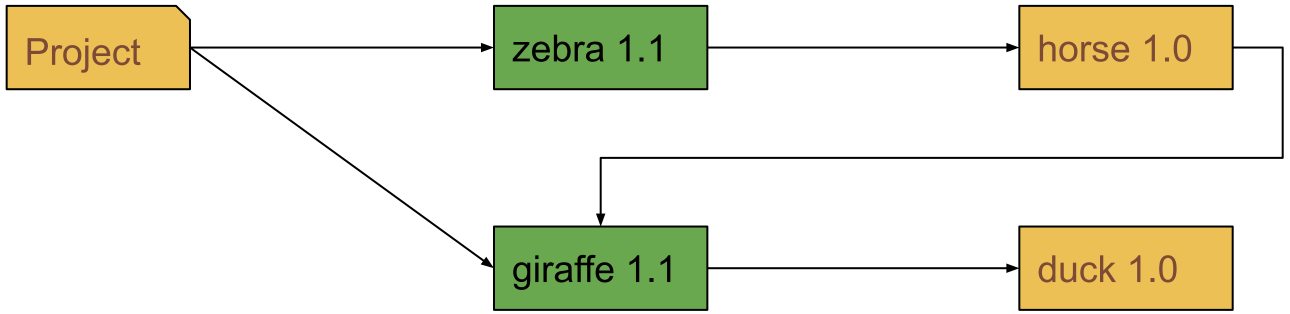
Partial Updates



```
$ composer update --dry-run zebra/zebra giraffe/giraffe
    Updating zebra/zebra (1.0 -> 1.1)
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```

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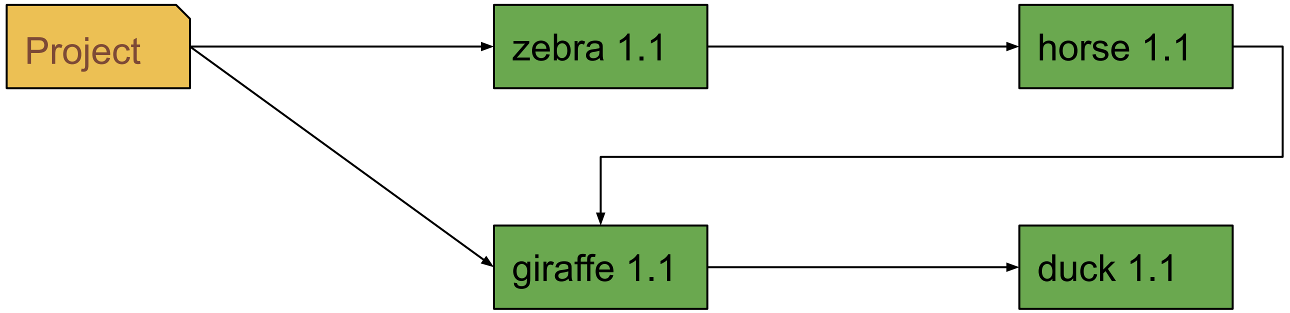
Partial Updates



```
$ composer update zebra/zebra giraffe/giraffe --with-dependencies
    Updating duck/duck (1.0 -> 1.1)
    Updating giraffe/giraffe (1.0 -> 1.1)
    Updating horse/horse (1.0 -> 1.1)
    Updating zebra/zebra (1.0 -> 1.1)
```

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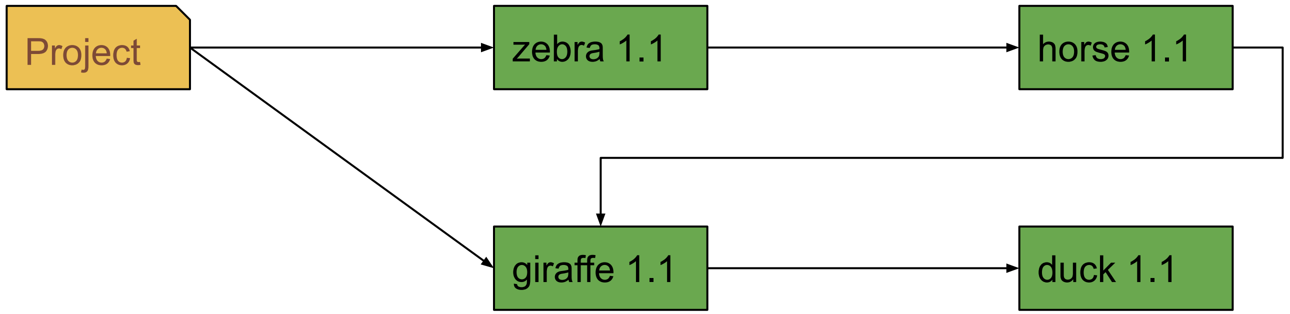
Partial Updates



```
$ composer update zebra/zebra --with-all-dependencies
    Updating duck/duck (1.0 -> 1.1)
    Updating giraffe/giraffe (1.0 -> 1.1)
    Updating horse/horse (1.0 -> 1.1)
    Updating zebra/zebra (1.0 -> 1.1)
```

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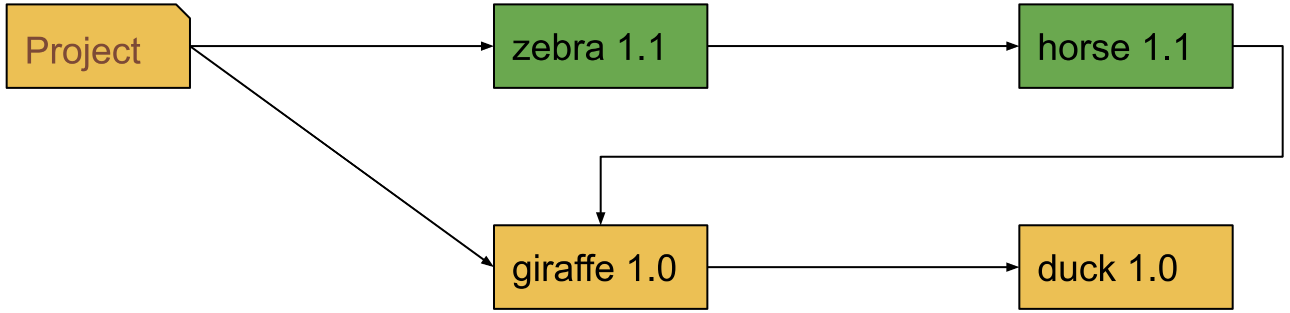
Partial Updates



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    Updating horse/horse (1.0 -> 1.1)
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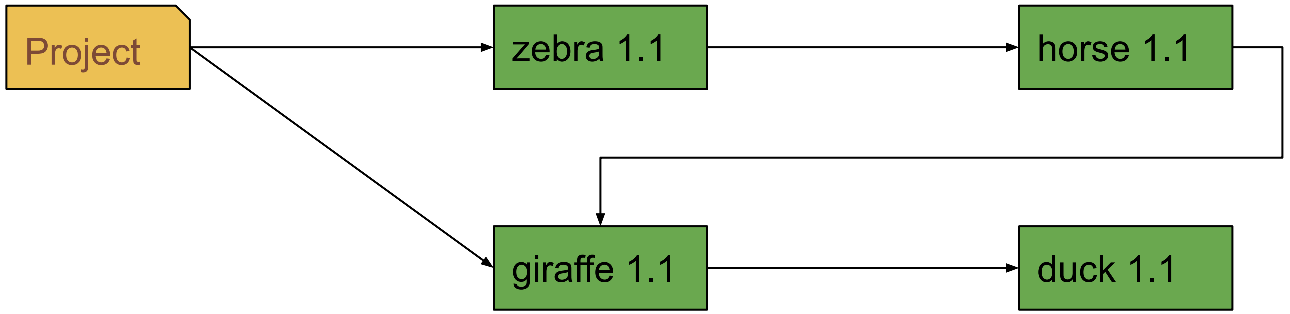
Partial Updates



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    Updating zebra/zebra (1.0 -> 1.1)
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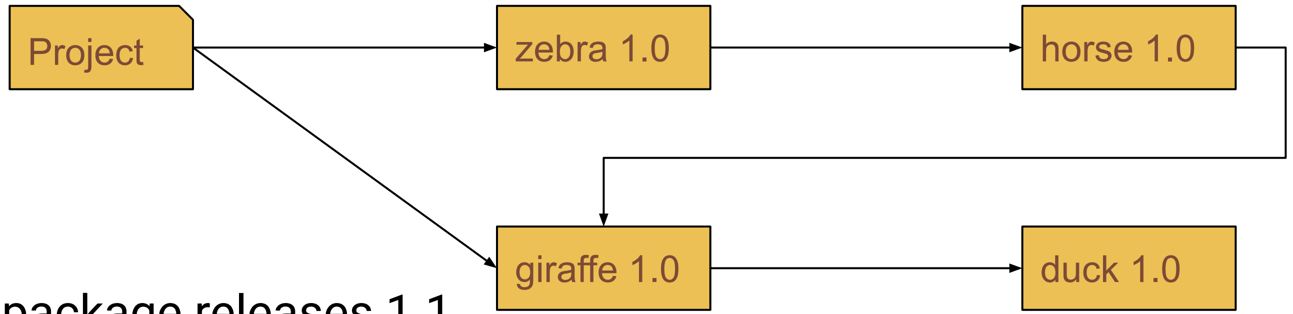
--minimal-changes

- --minimal-changes
  - Since Composer 2.7 (Feb 8, 2024)
  - Problem: I want to update one dependency, but there’s a conflict, I need to update more, but I don’t want to update everything
  - Solution: Partial updates with dependencies, but keeping them at the same version as the lock file if possible

--minimal-changes



Now each package releases 1.1

- zebra 1.1 requires horse ^1.1
- horse 1.1 requires giraffe ^1.1
- giraffe 1.1 still requires **duck ^1.0**

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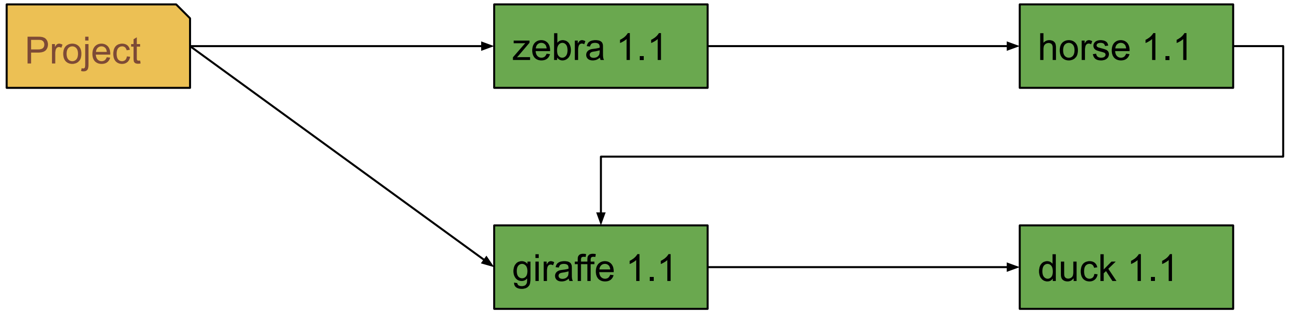
--minimal-changes



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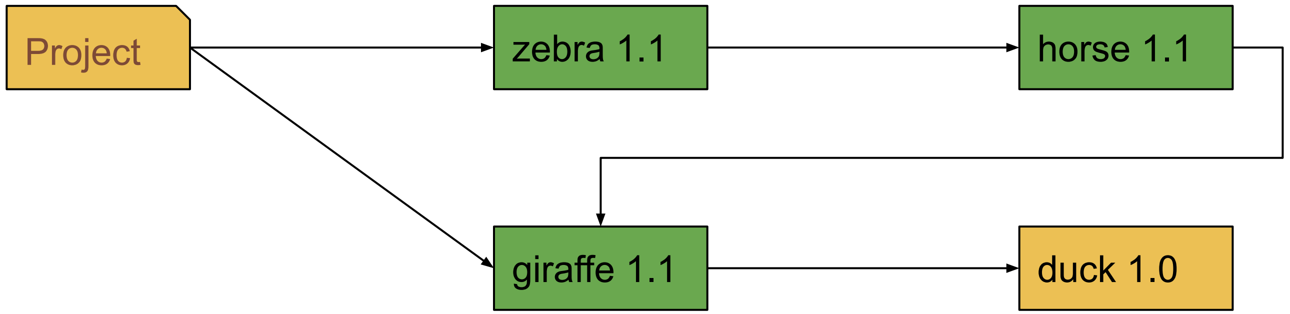

```
$ composer update zebra/zebra --with-all-dependencies --minimal-changes
    Updating giraffe/giraffe (1.0 -> 1.1)
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    Updating zebra/zebra (1.0 -> 1.1)
```

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Who could follow earlier? Any idea how to implement this?

--minimal-changes

Who could follow the beginning? Any idea how to implement this?

- Set up the update the same way as if the option wasn't specified
- Make the policy pick locked version numbers before any other versions
- Result
    - Solver will try locked versions first
    - If locked versions are incompatible it will attempt to change versions

https://github.com/composer/composer/pull/11665

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Introducing

Conductor

By PRIVATE PACKAGIST

Automatic dependency updates for Composer

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Questions / Feedback?

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