

# PartnerRe

## Long Term Protection Model in R

Dr. Urszula Gasser, Senior Pricing Actuary

PartnerRe





## **Disclaimer**

**The following presentation is for general information, education and discussion purposes only.**

**Views or opinions expressed, whether oral or in writing do not necessarily reflect those of PartnerRe nor do they constitute legal or professional advice.**





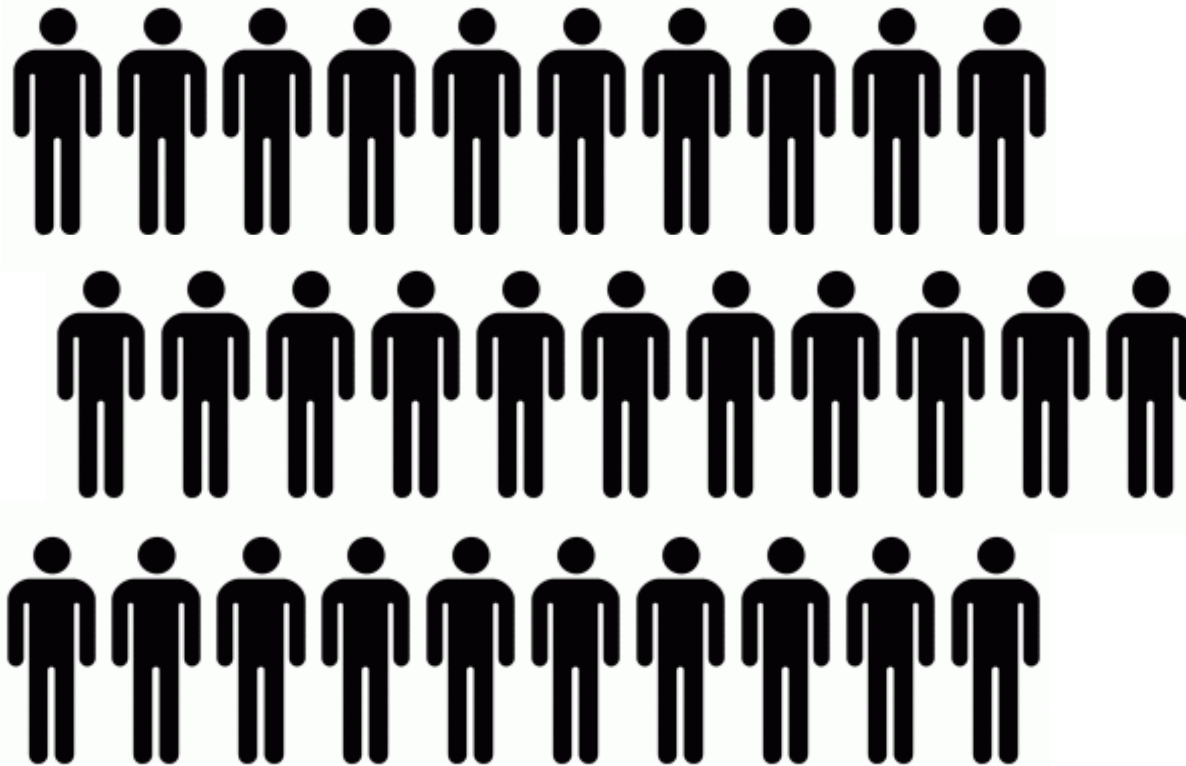
# The need





## Life insurance

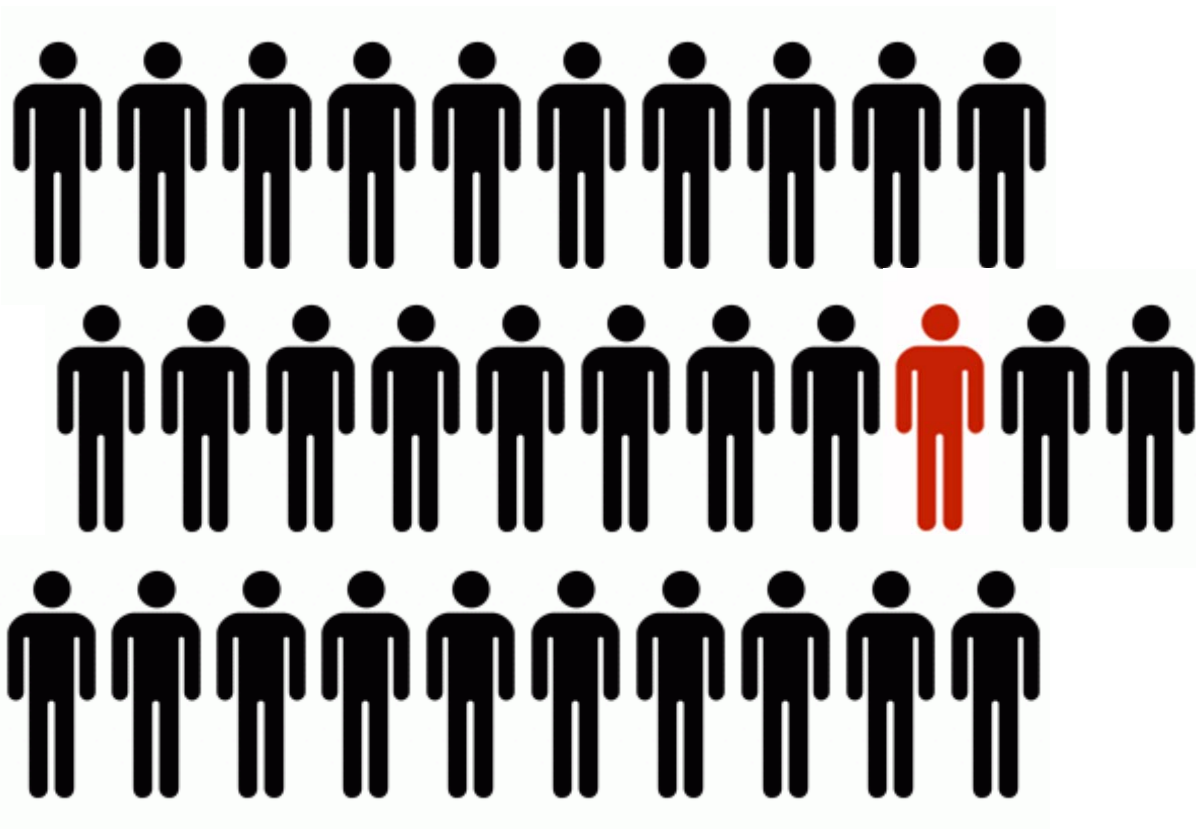
Gives protection against loss resulting from death (or serious illness) of an insured





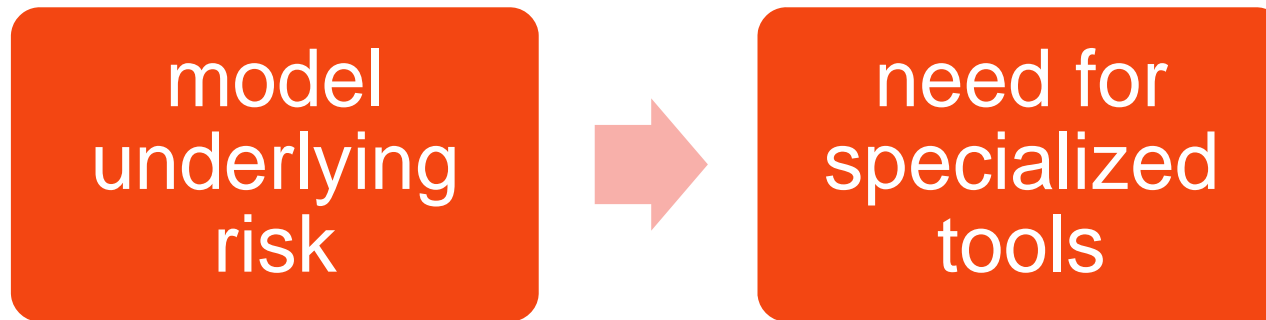
## Life insurance

Gives protection against loss resulting from death (or serious illness) of an insured





## Life reinsurer needs to...





# The model





## What about Mr Bloggs?

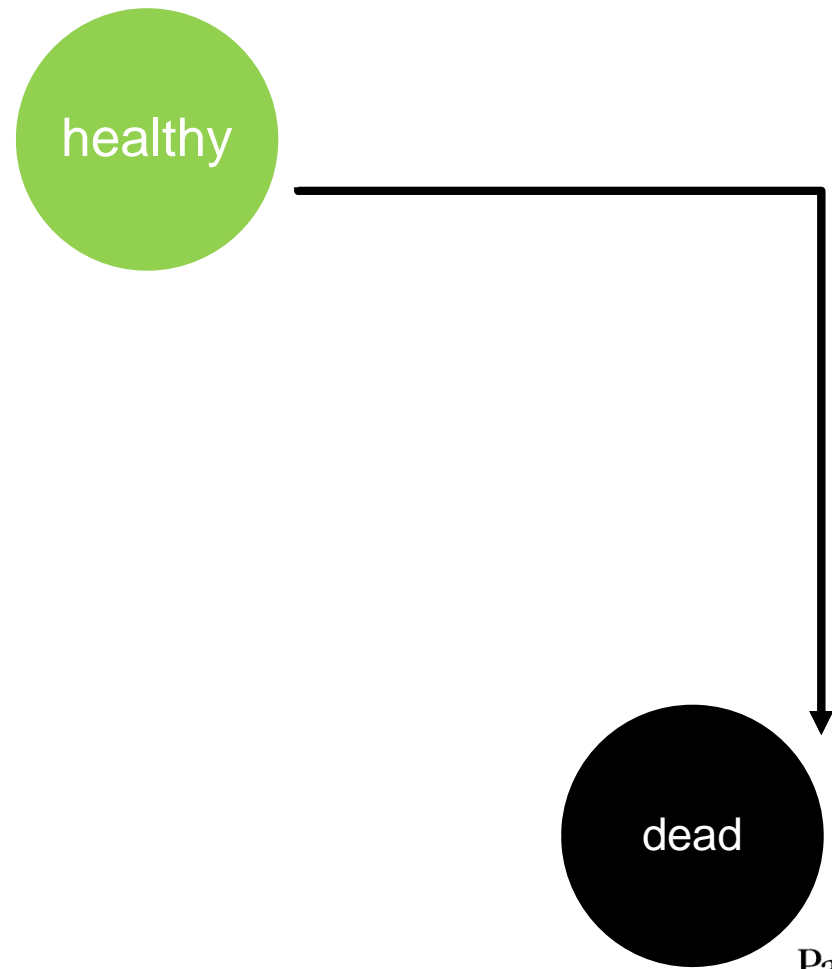
healthy







# What about Mr Bloggs?

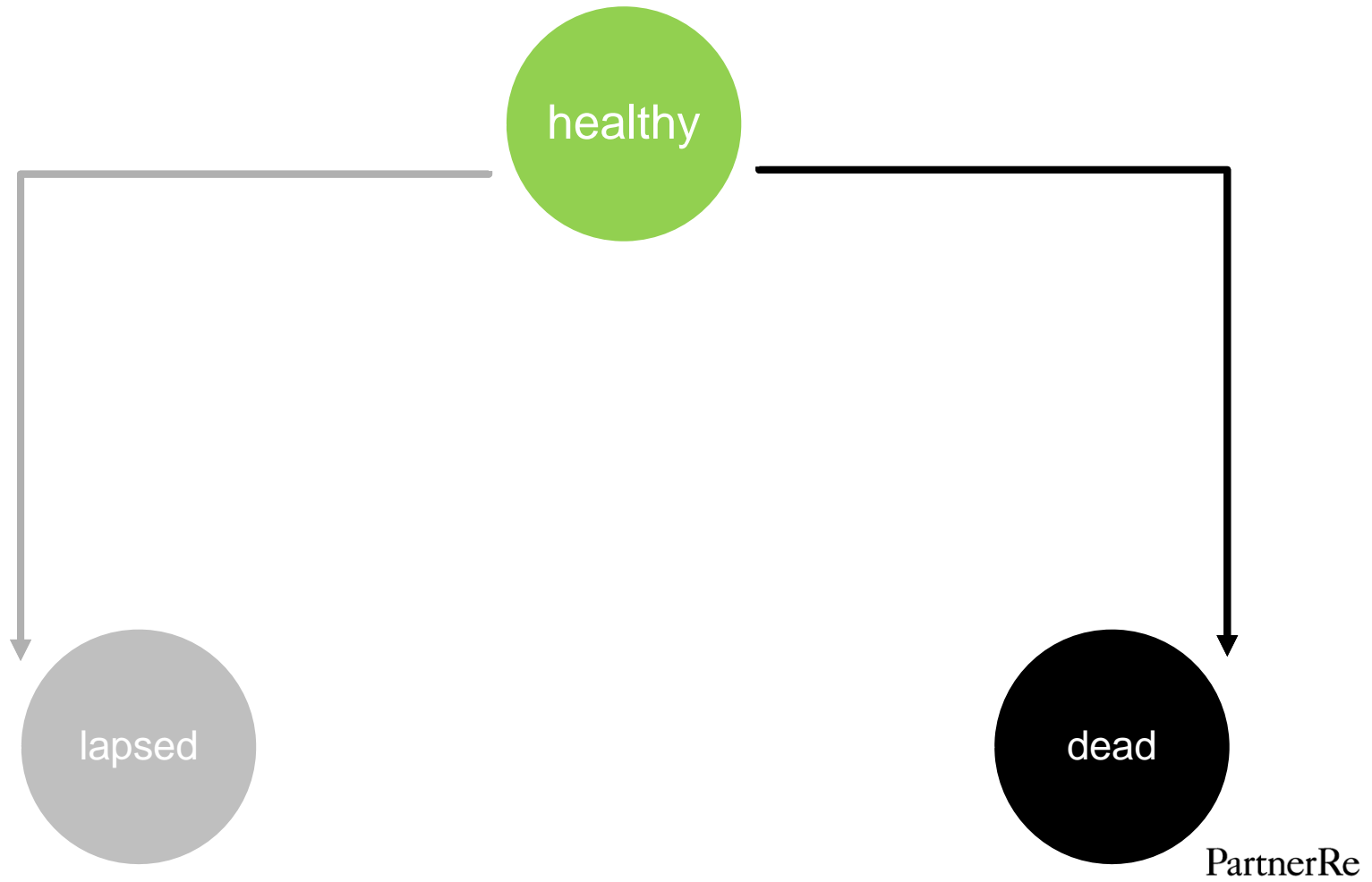


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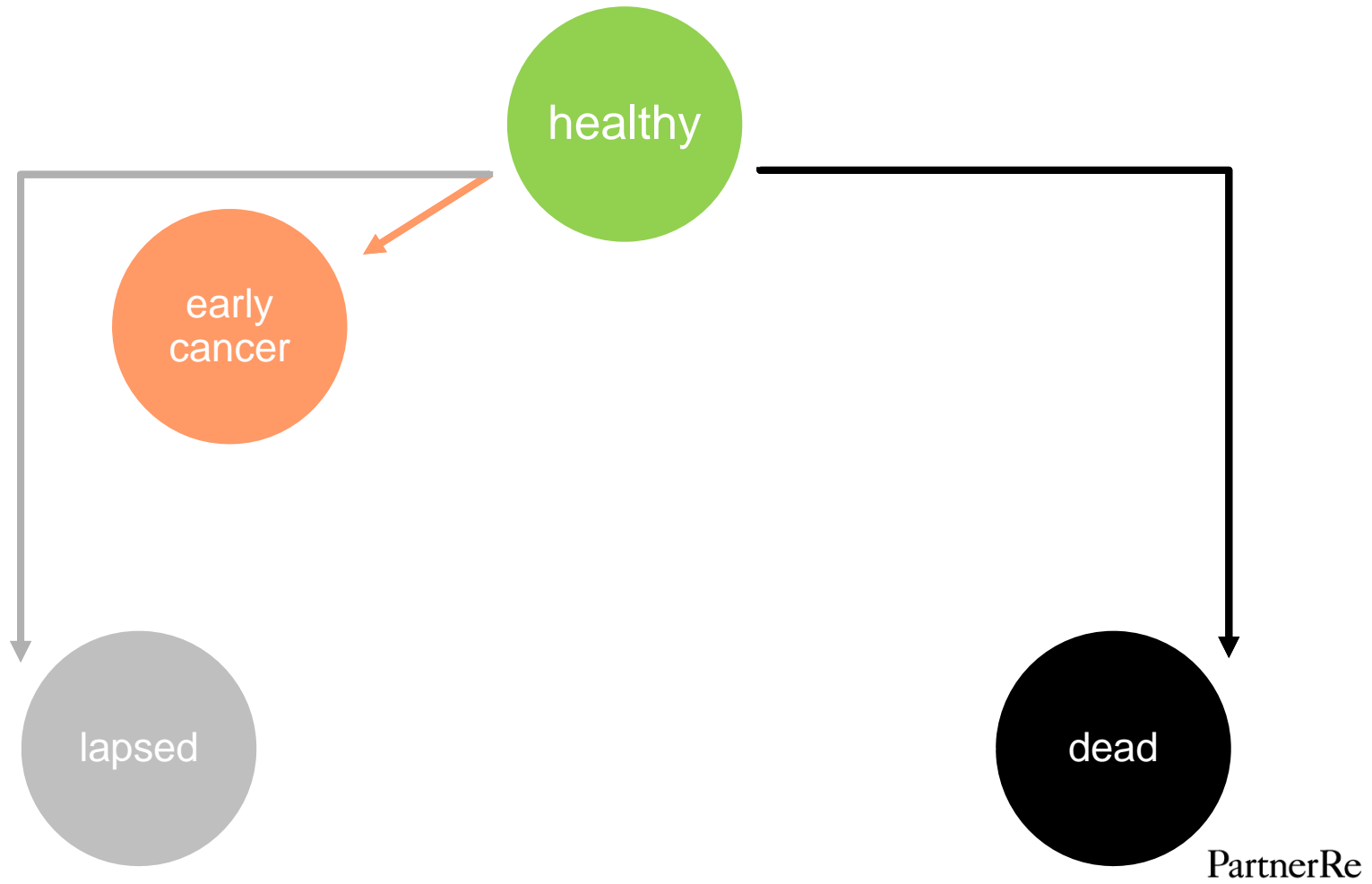


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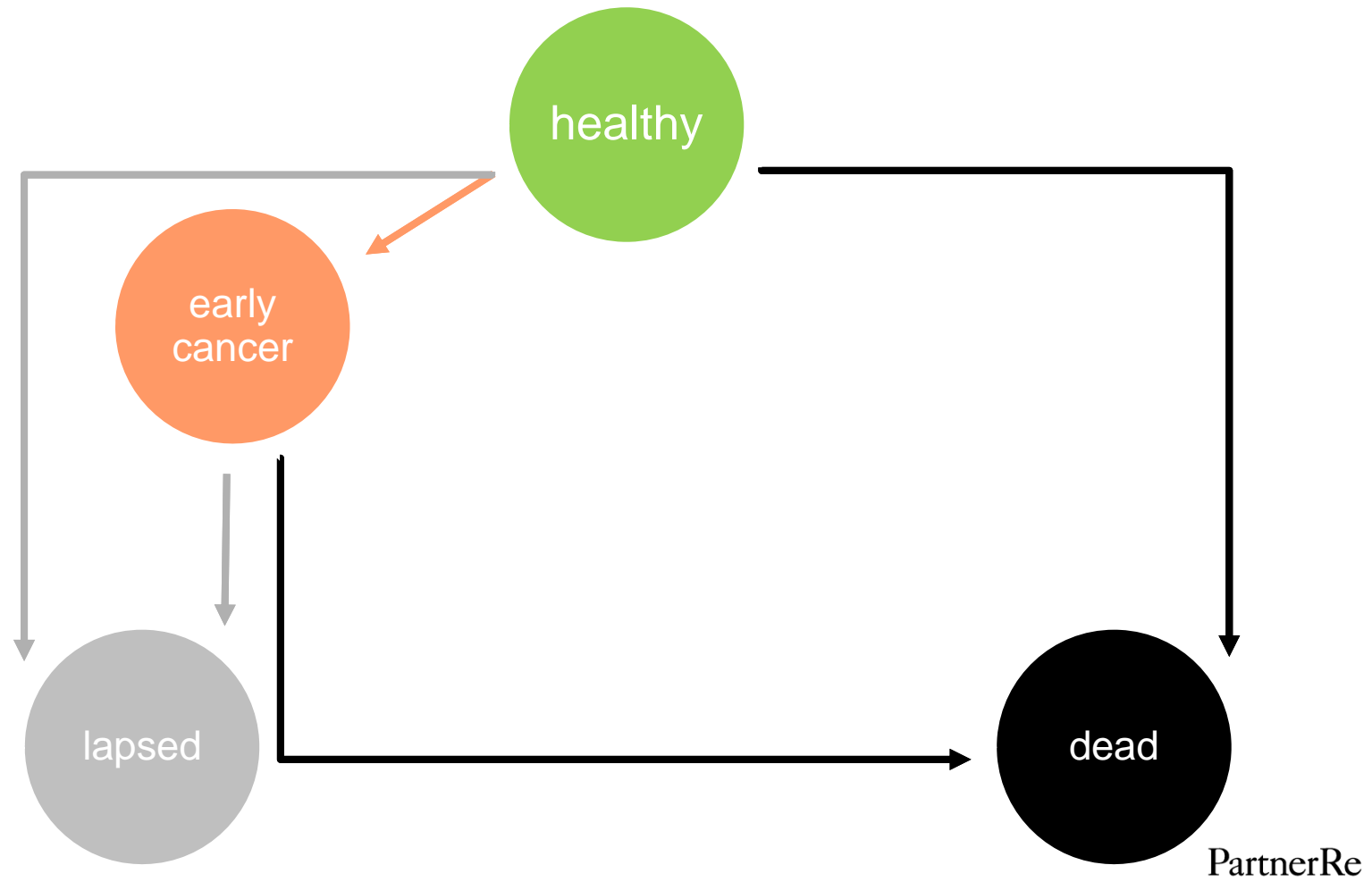


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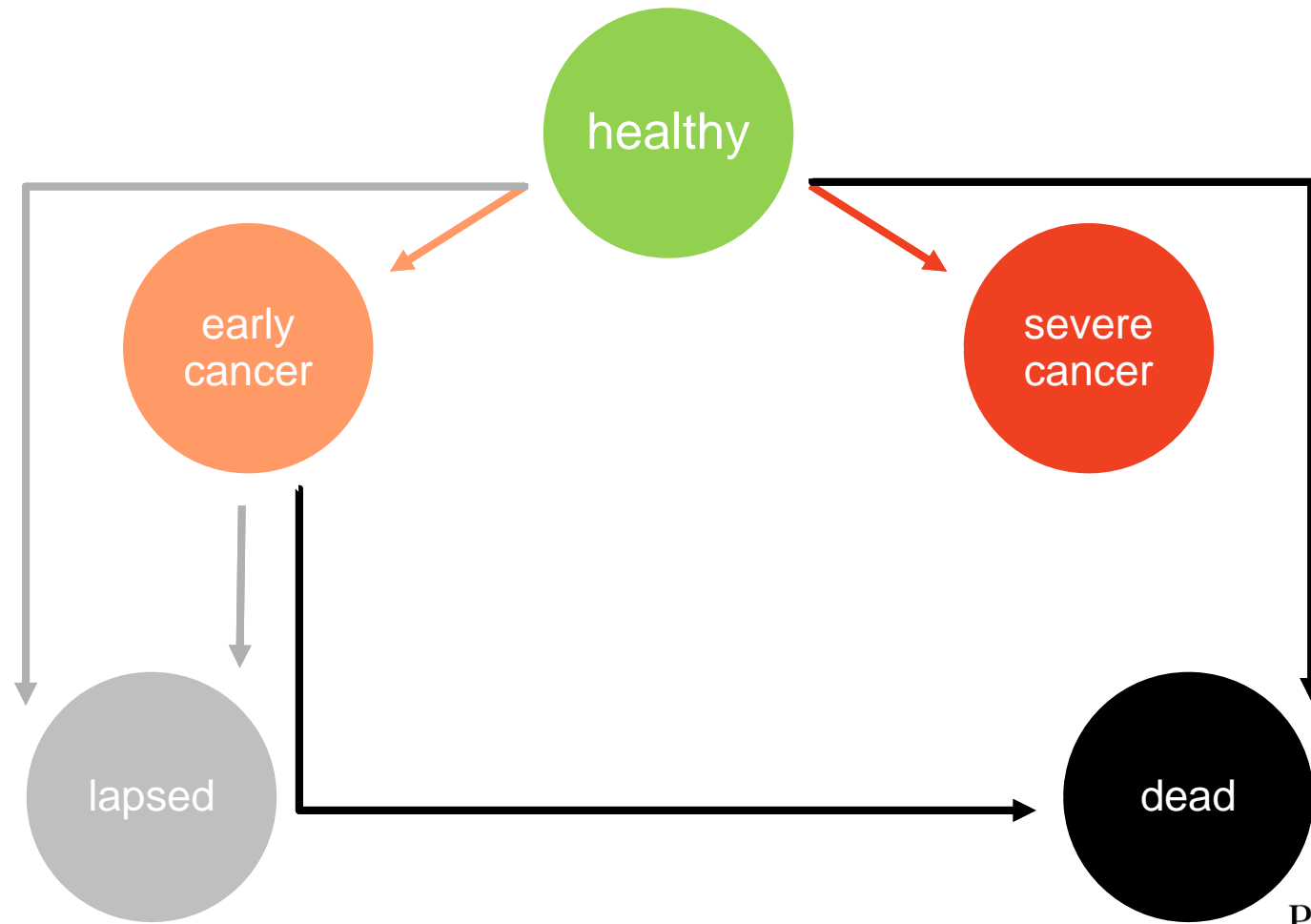


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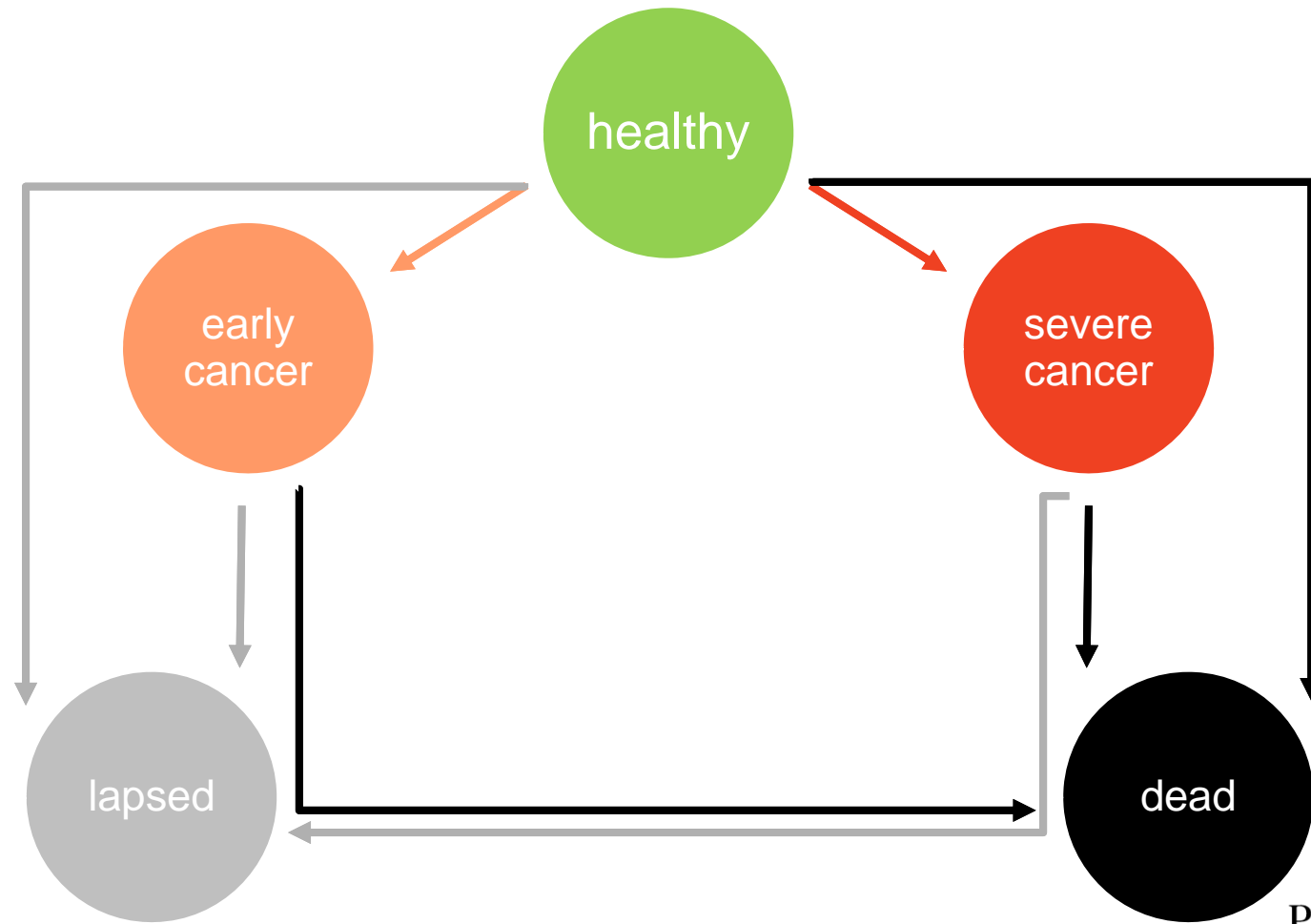


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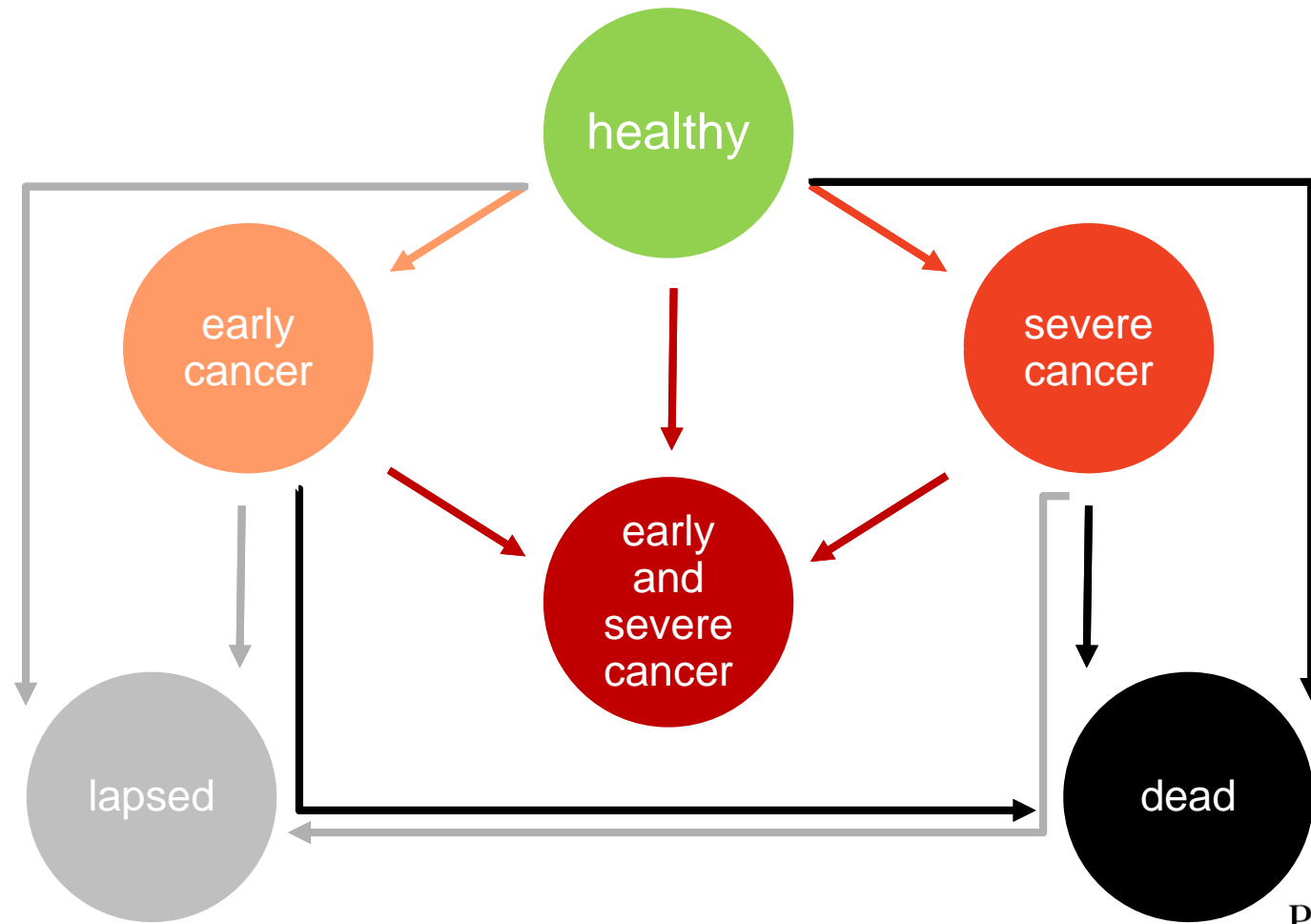


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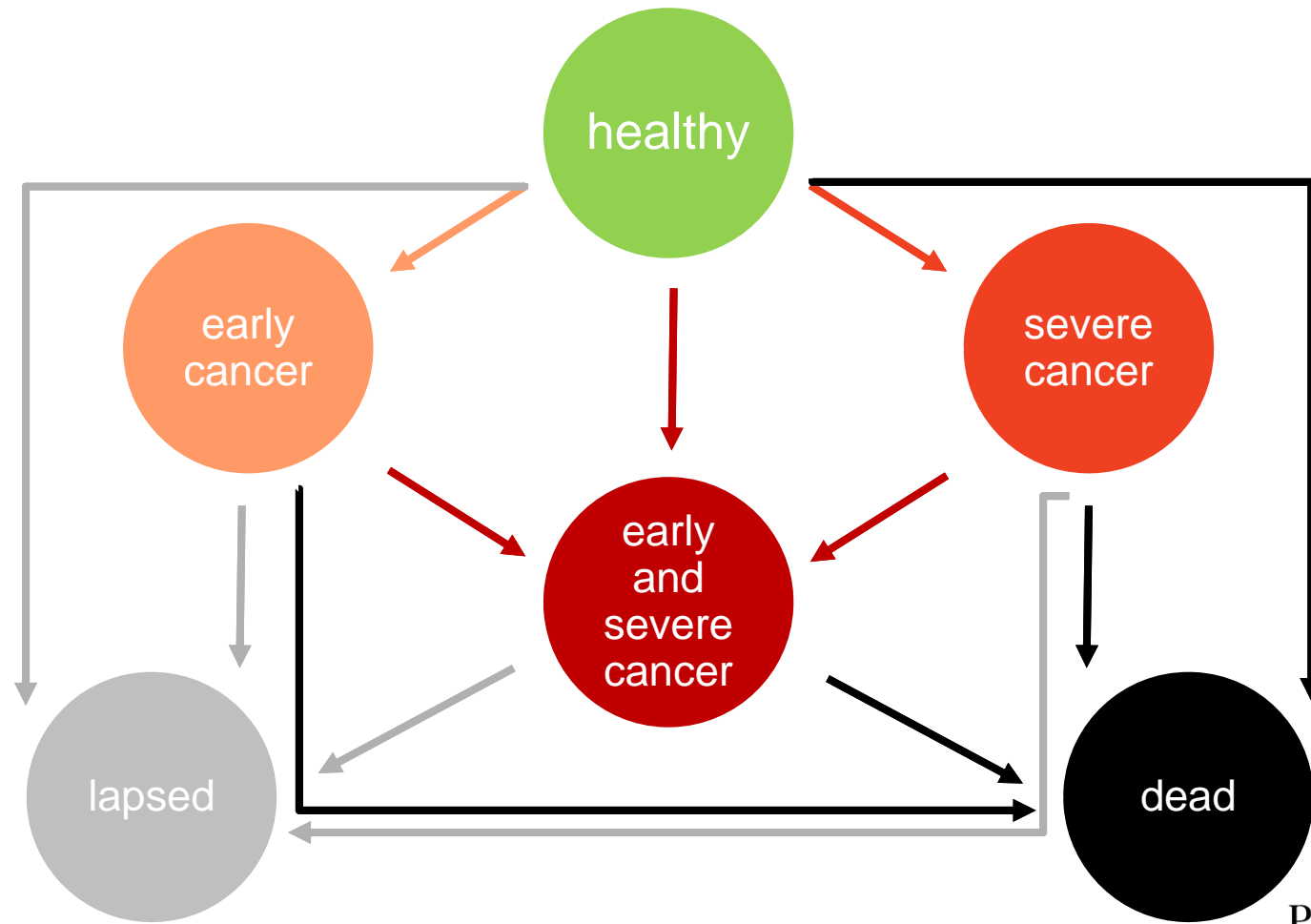


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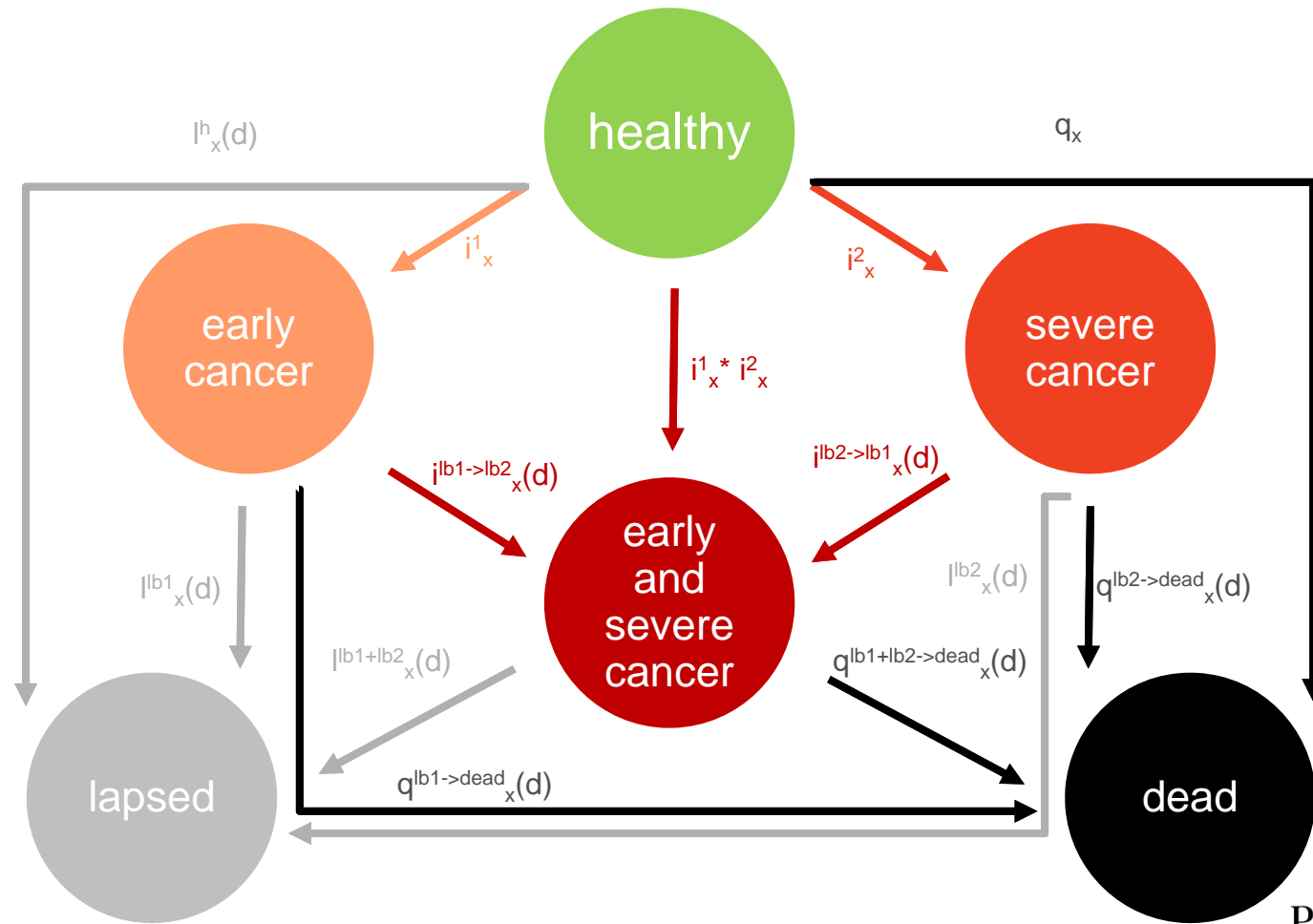
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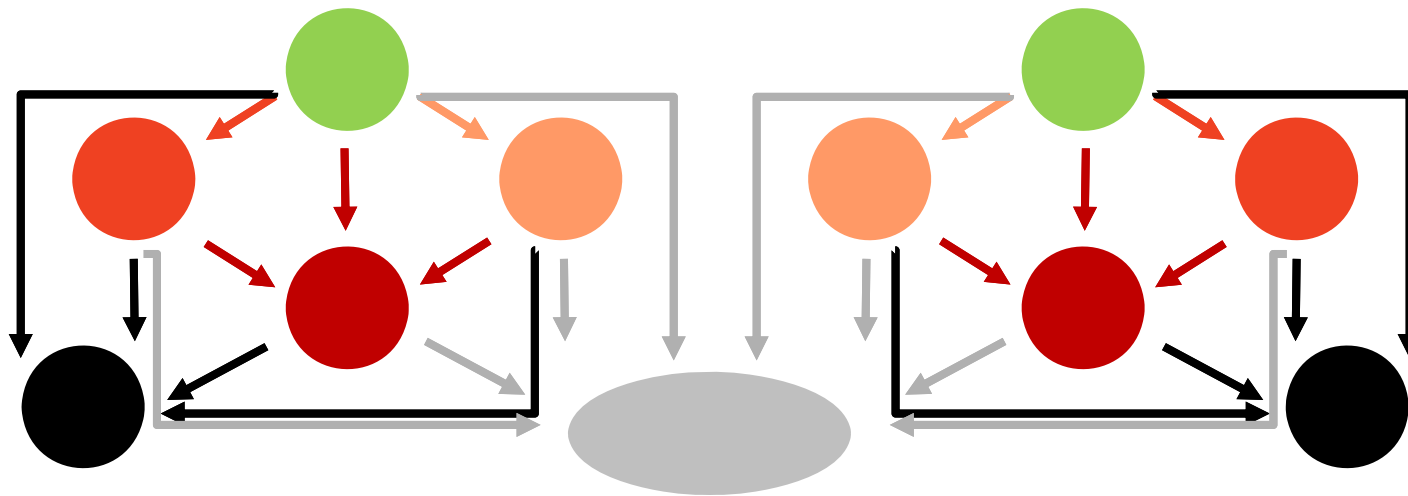
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$q_x, i_x, l_x$  – mortality rate, incidence rate, lapse rate  
 $d$  – duration (months) in given state





## And what about Mrs Bloggs?





To model Mr & Mrs Bloggs policy

we decided to build our own, **Long Term Protection Model** for pricing





# The tool





## **LTPM pricing tool needs to be**

- **User friendly**
  - Easy to access
  - Simple to set-up
  - Fast to calculate
  - Straightforward to interpret
- **Flexible**
- **Stable**
- **Secure**
- **Auditable**





## We decided to do it in R

as opposed to most tools used in the re/insurance industry,

because these come often with:

- Legacy issues (too heavy)
- Calculation constraints (some things are not possible)
- Access issues (desktop versions, use of “workers”, external clouds)
- Transparency issues (black-box)
- Maintenance issues (costly upgrade, adaptation)





## Why R?

- **Becoming the standard analytics tool at university level and in many industries**
- **Free**
- **Open source**
- **Meets our needs**
  - Fast
  - Flexible
- **Reduces the number of platforms we maintain**





**R is an excellent fit...**

**... but we also need an infrastructure to support all the tool requirements**





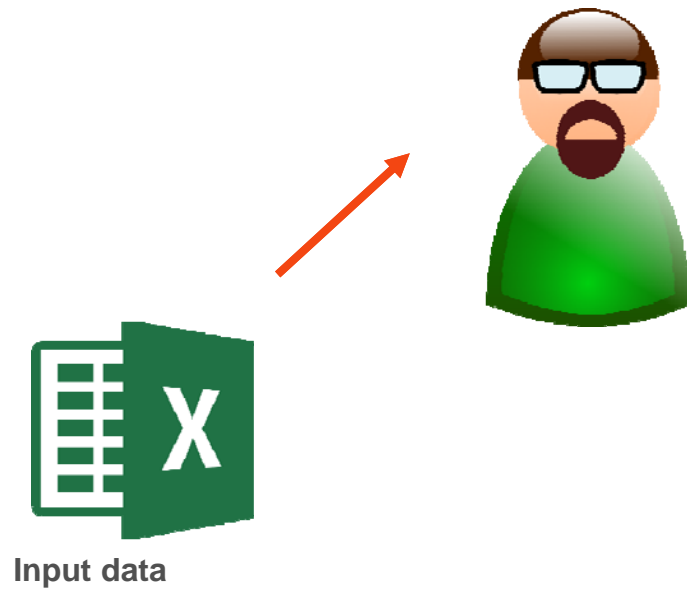


# The workflow



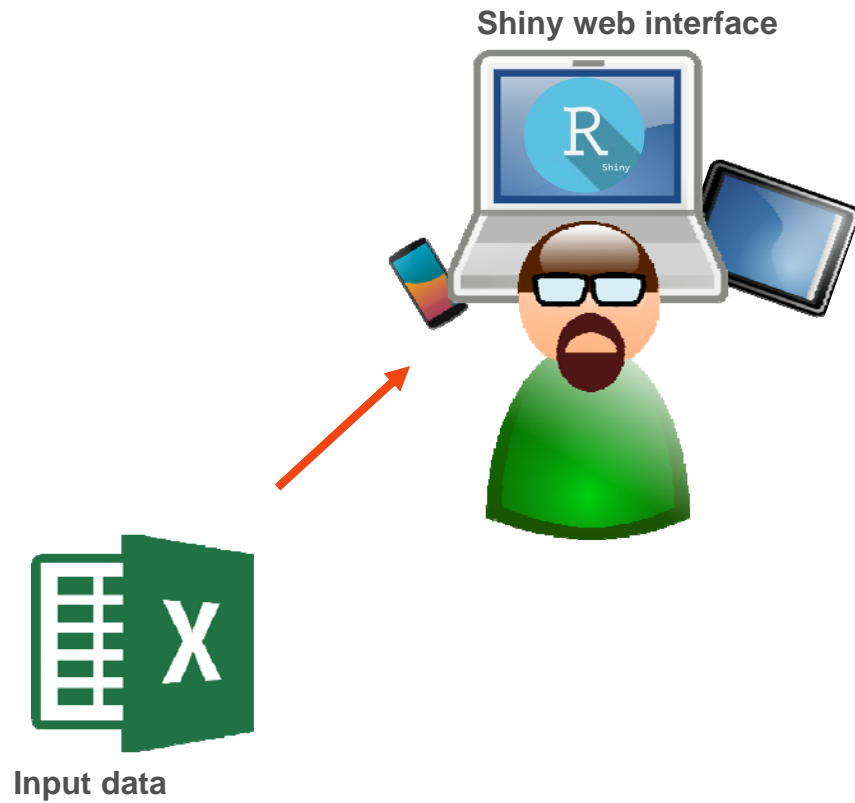


## First, let's look at the steps in the calculation



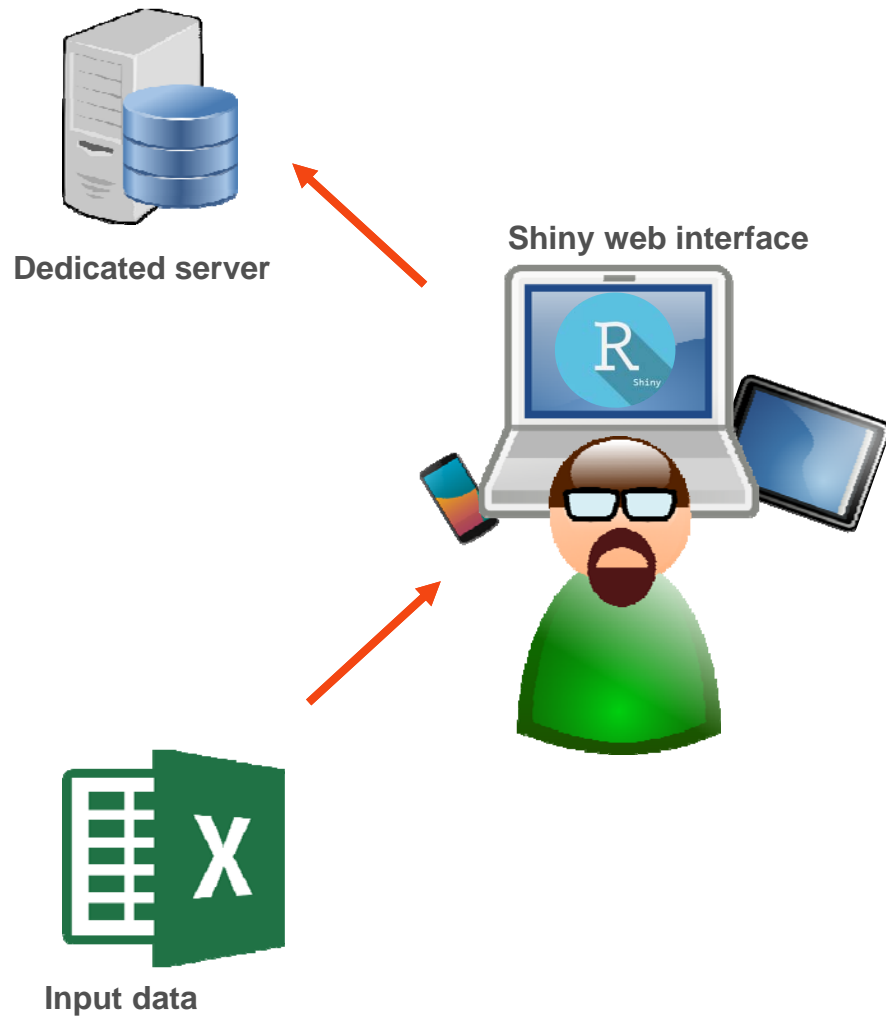


# Steps in the calculation



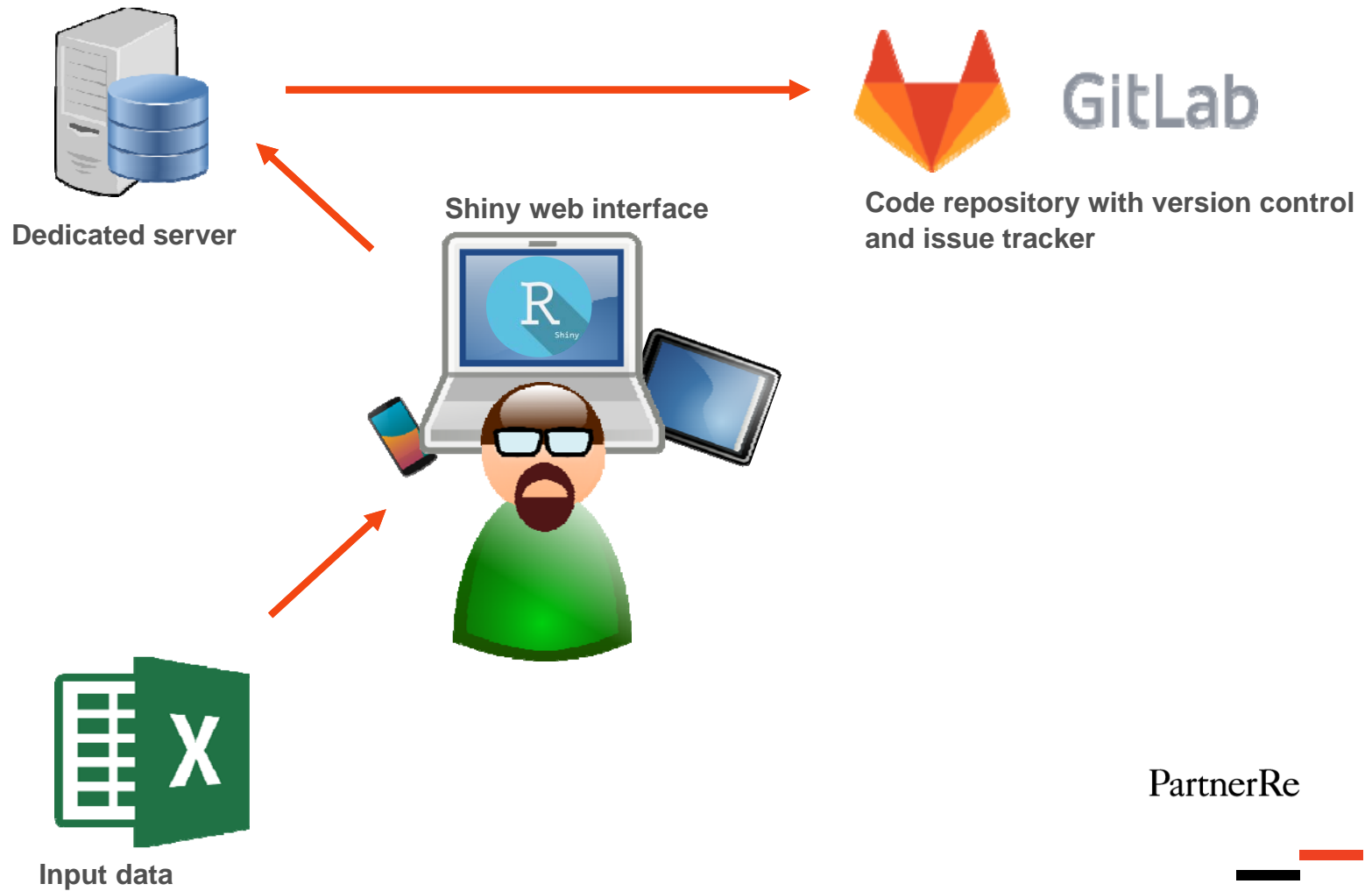


## Steps in the calculation



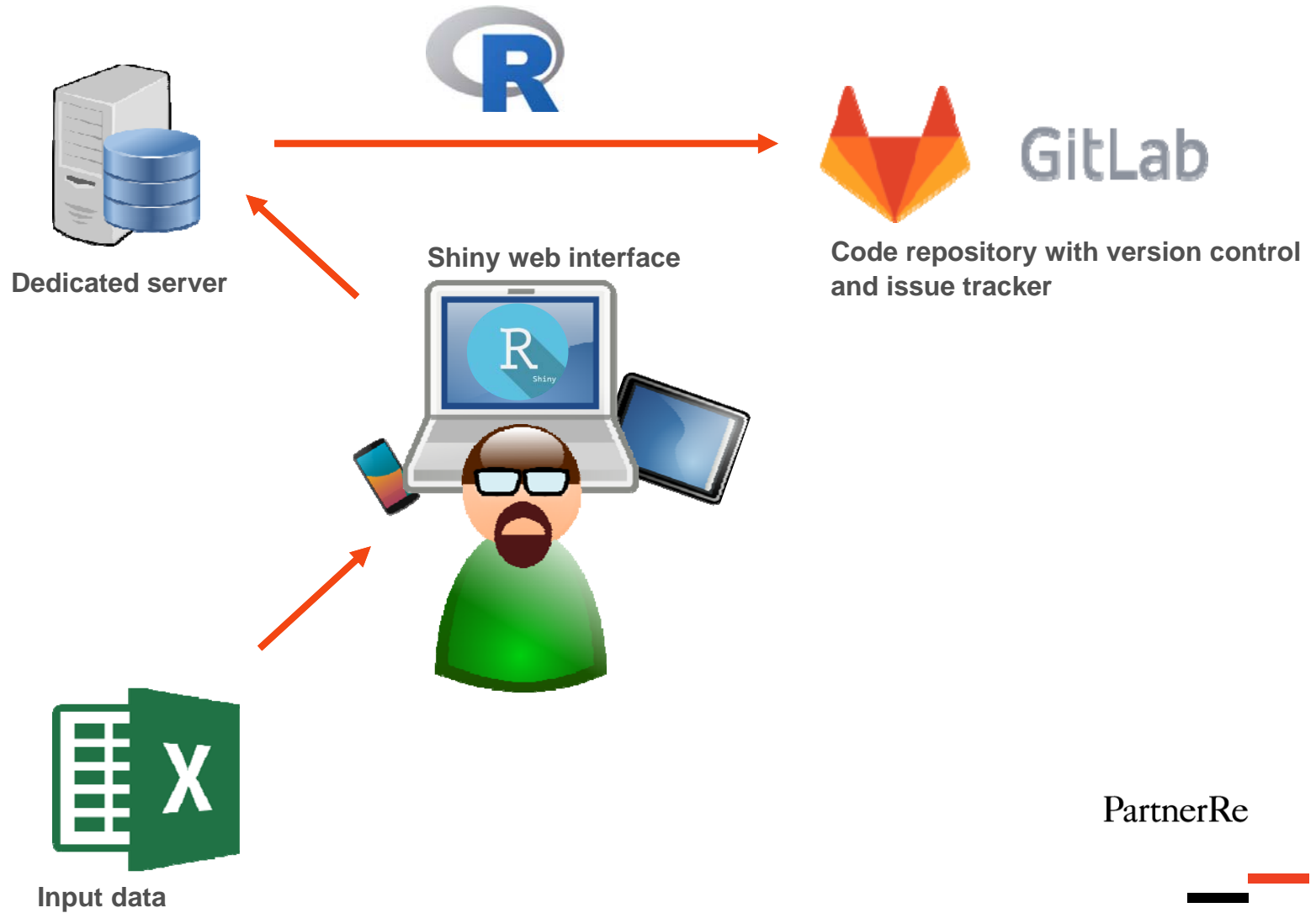


## Steps in the calculation



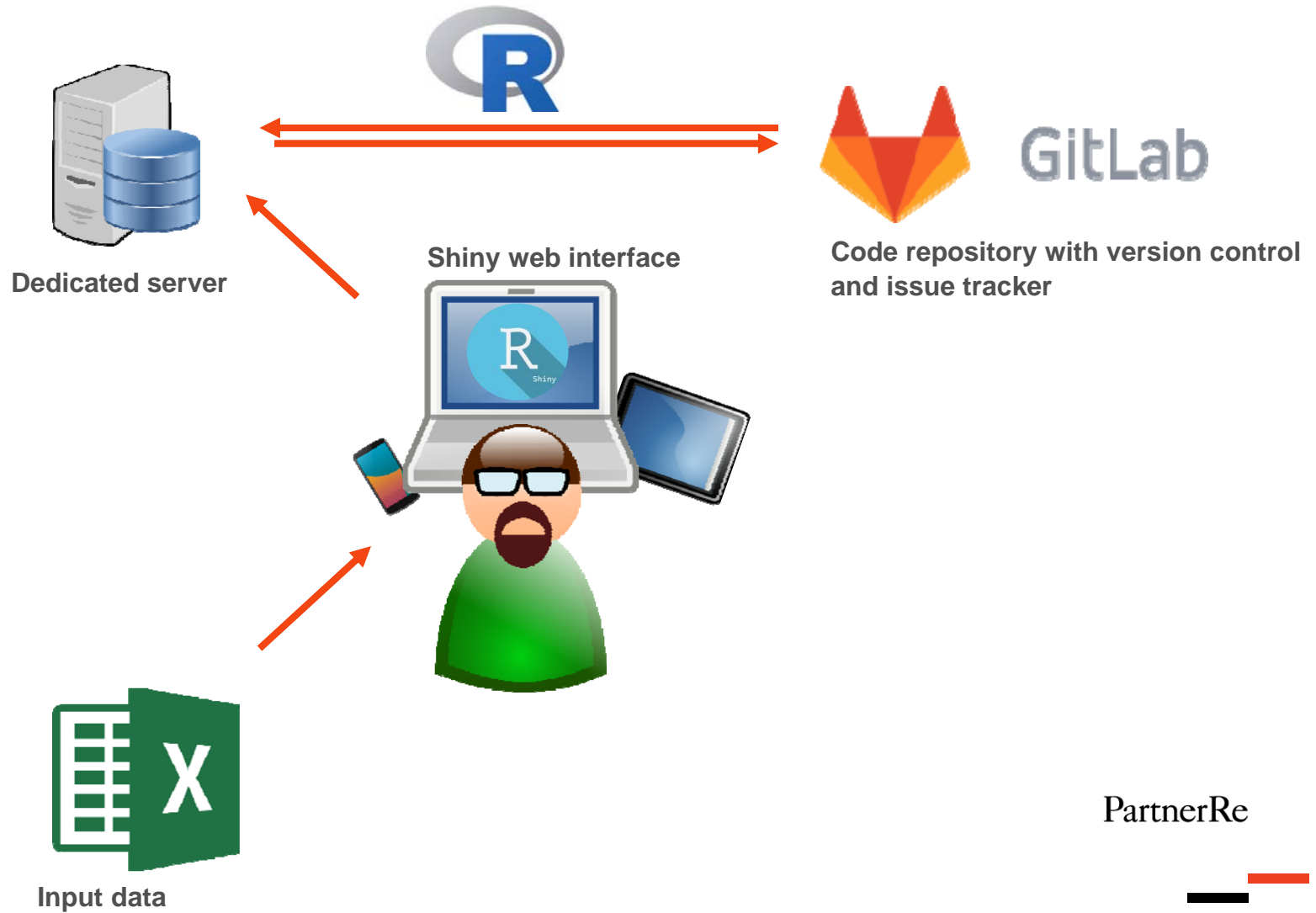


## Steps in the calculation



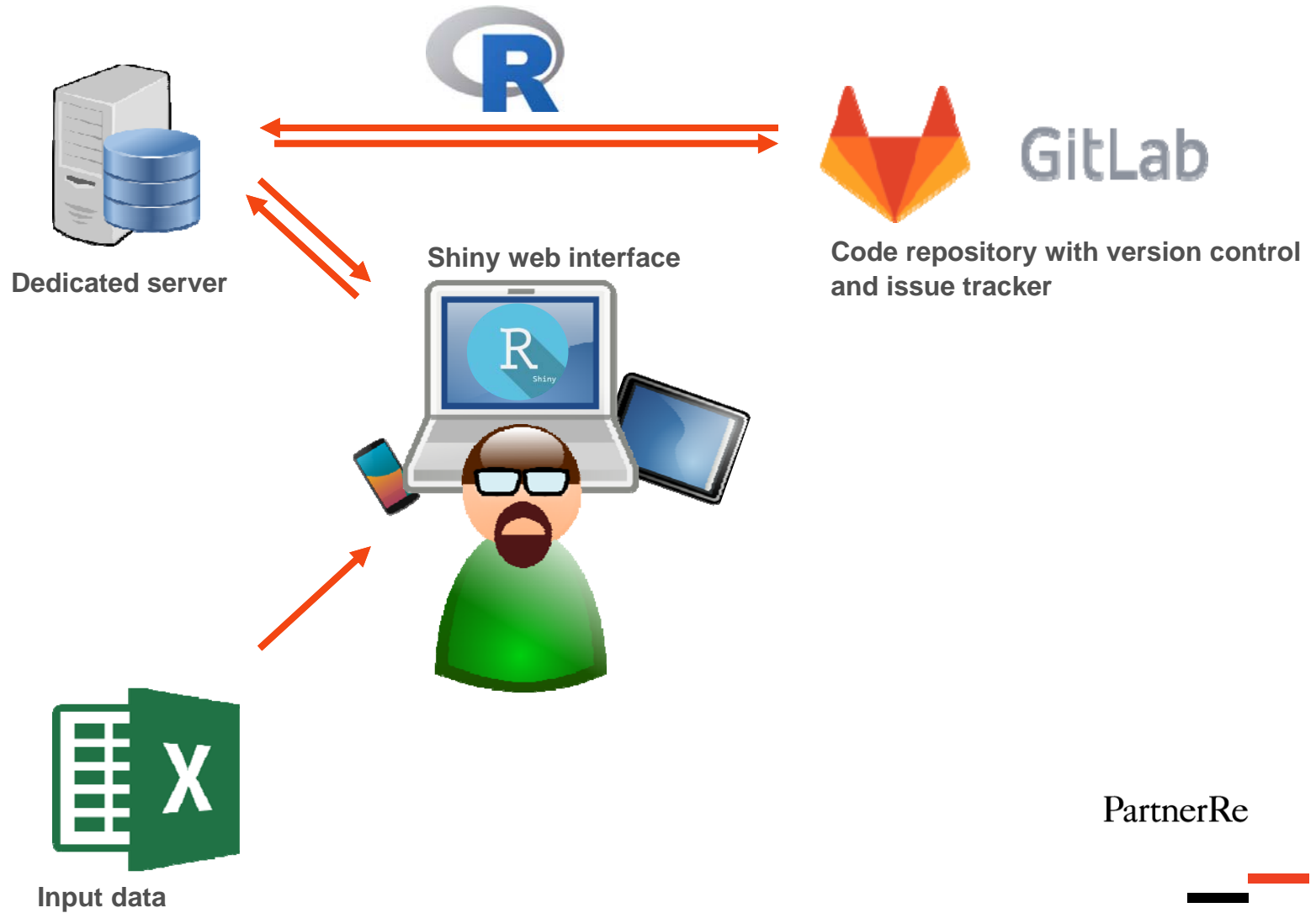


## Steps in the calculation





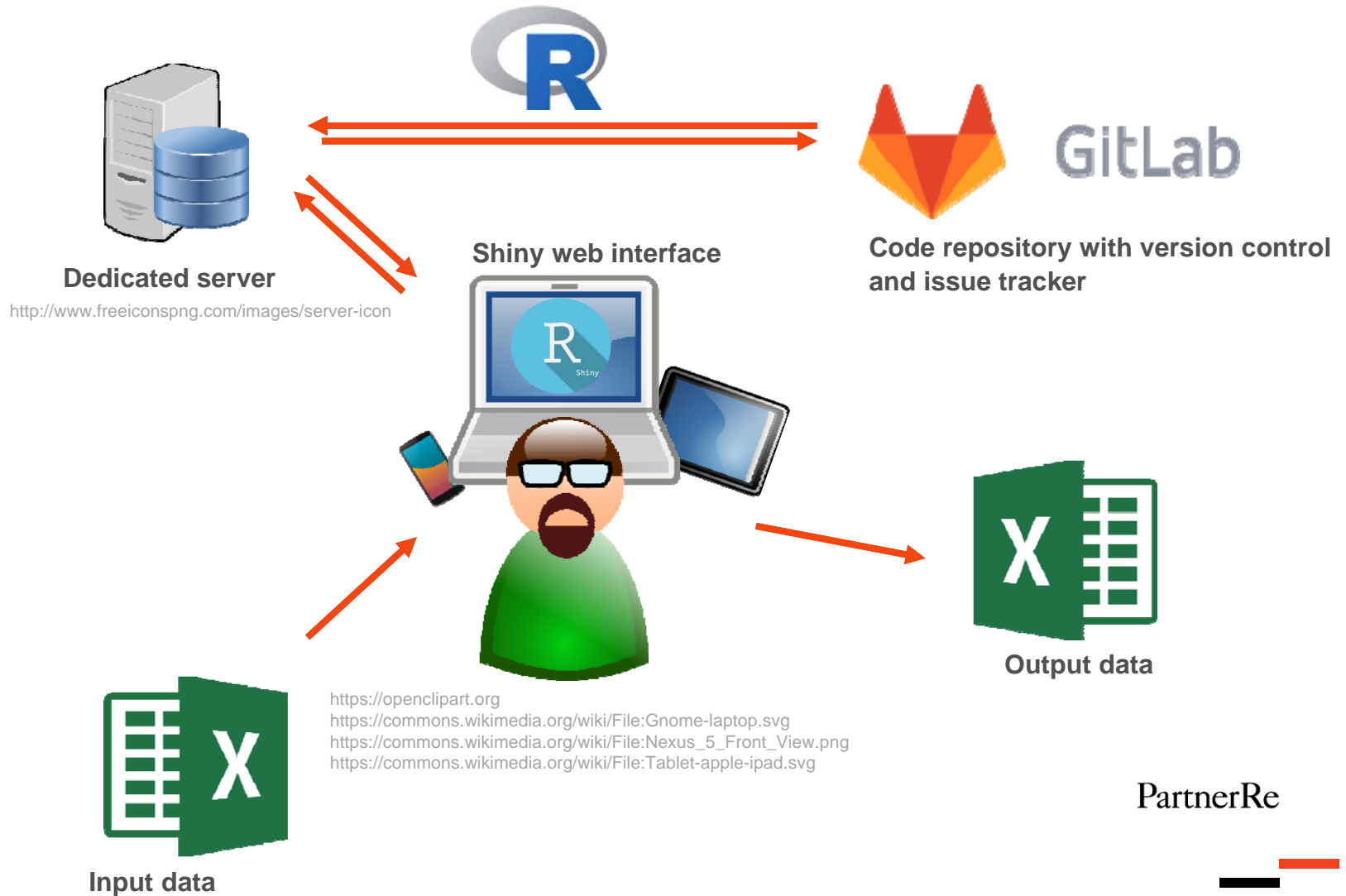
## Steps in the calculation







# Steps in the calculation





# The interface





## Pricing exercise

Select an existing pricing exercise

Or enter a name to create a new pricing exercise:

## Calculation runs

Create a new run

Select a model version to use

Enter a name for the run (or use suggested name)

Select a \*.xslm file to upload

No file uploaded.





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Enter a name for the run (or use suggested name)

← intuitive names

Select a \*.xslm file to upload

The screenshot shows a web browser window with the URL `ltpmtest/home/`. The page is titled "Pricing exercise" and "Calculation runs".

**Pricing exercise section:**

- Label: "Select an existing pricing exercise" (← web interface)
- Dropdown menu: "Demo" (← collaboration)
- Text: "Or enter a name to create a new pricing exercise:"
- Input field: (empty)

**Calculation runs section (light blue background):**

- Section header: "Calculation runs"
- Section header: "Create a new run"
- Text: "Select a model version to use" (← choice of model version)
- Dropdown menu: "latest"
- Text: "No file uploaded."
- Text: "Enter a name for the run (or use suggested name)" (← intuitive names)
- Input field: "Simple run"
- Text: "Select a \*.xslm file to upload" (← upload of the input data)
- File selection: "Browse..." button, "Simple input.xslm" file selected





## Model version

This model is based on commit

**7f8dc01f22a8289b191a855e50598b0cc9a1b9c4**

from [git@gitlab:LTPM/LTPMrun.git](https://gitlab.com/ltpm/LTPM/LTPMrun.git)

## Run details

- Name: Simple run
- Exercise: Demo
- Created: 2017-08-30T12:15:12Z
- Input file: Simple input.xlsm ( 16635 kB )
- Model points: 1

## Controls

Run has completed, no action available.

## Log messages

Last 10 messages:

```
[2017-08-30 08:18:02 EDT] INFO: writing table mp-33-calcSumsReinsured to file output/mp-33-calcSumsReinsured.csv
[2017-08-30 08:18:02 EDT] INFO: writing table mp-33-calcClaims to file output/mp-33-calcClaims.csv
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```

[Download complete log](#)

[Download complete run](#)

## Status

Status of recent runs:

- run 1334924316 started on August 30, 2017 at 12:17:12 GMT, completed after 50.1 seconds

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Long-Term Protection M x LTPM x

ltpmtest/runs/exercise\_Demo-for-EARL-London/run-2017-08-30T12-15-01Z-Simple-run-guest/

LTPM Run Input Output

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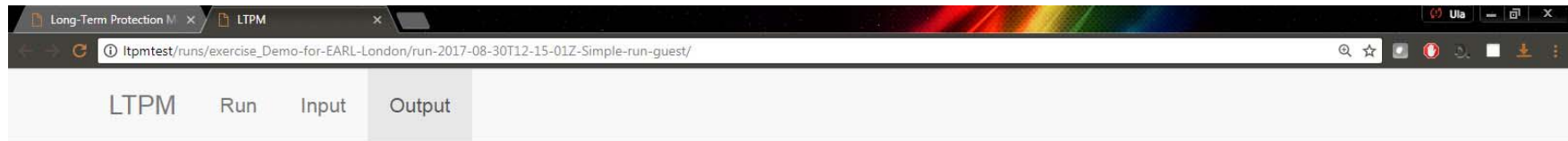
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[Download complete log](#)

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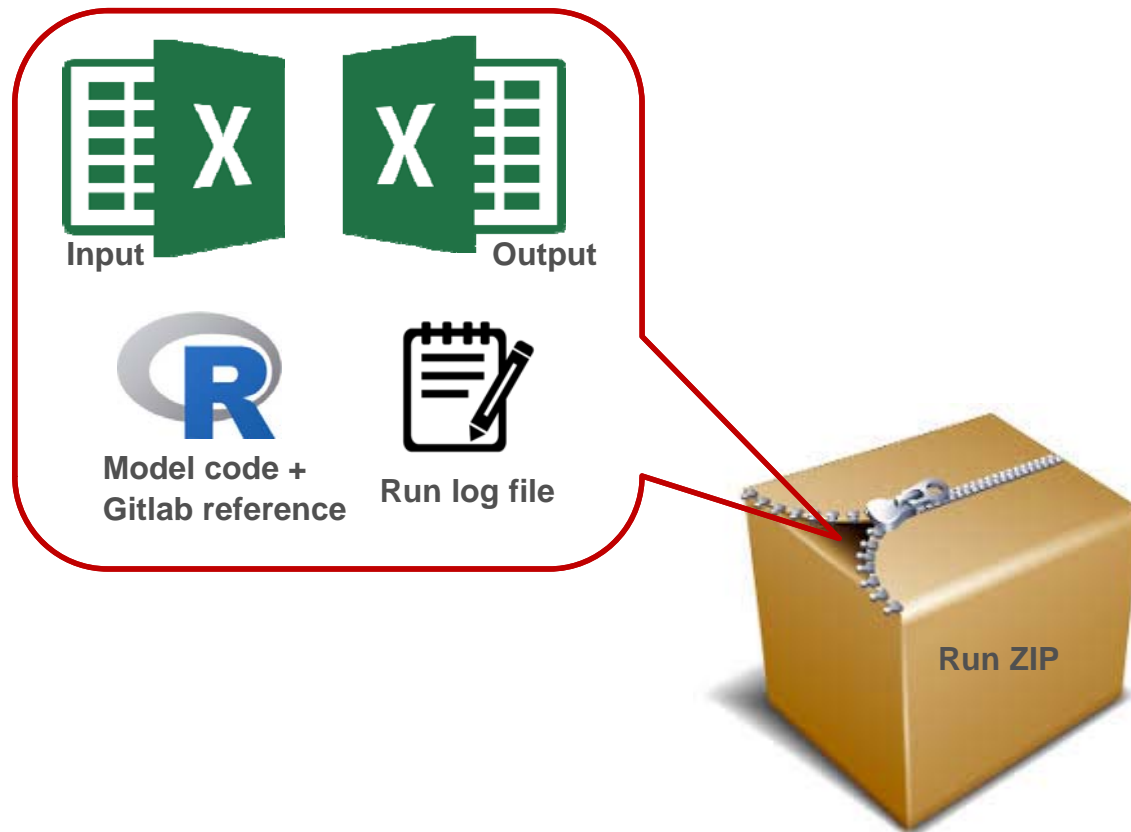
## Generated output

- mp-33-calcClaims.csv [ [download](#) ]
- mp-33-calcCommissions.csv [ [download](#) ]
- mp-33-calcIncidenceDeath.csv [ [download](#) ]
- mp-33-calcIncidenceLb1.csv [ [download](#) ]
- mp-33-calcInforce.csv [ [download](#) ]
- mp-33-calcPostIncidenceDeathFromLb1.csv [ [download](#) ]
- mp-33-calcPremiumRates.csv [ [download](#) ]
- mp-33-calcPremiums.csv [ [download](#) ]
- mp-33-calcSumsAssured.csv [ [download](#) ]
- mp-33-calcSumsReinsured.csv [ [download](#) ]
- mp-33-calcWop.csv [ [download](#) ]
- mp-33-cashFlows.csv [ [download](#) ]
- mp-33-getBaseIncidenceRateDeath.csv [ [download](#) ]
- mp-33-getBaseIncidenceRateLb1.csv [ [download](#) ]
- mp-33-getIncidenceImprovFactorDeath.csv [ [download](#) ]
- mp-33-getIncidenceImprovFactorLb1.csv [ [download](#) ]
- mp-33-getLapseRateFromHealthy.csv [ [download](#) ]
- mp-33-getLapseRateFromLb1.csv [ [download](#) ]





## Content of a run





# The anatomy





# GitLab repository

LTPM

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## Shiny applications

There are two Shiny applications in the LTPM:

1. **LTPMcreate**: the main application where pricing exercises can be defined and runs can be created.
2. **LTPMrun**: an interface to each individual run which displays run details (e.g. input files and settings), status messages, and provides access to results.





# GitLab repository

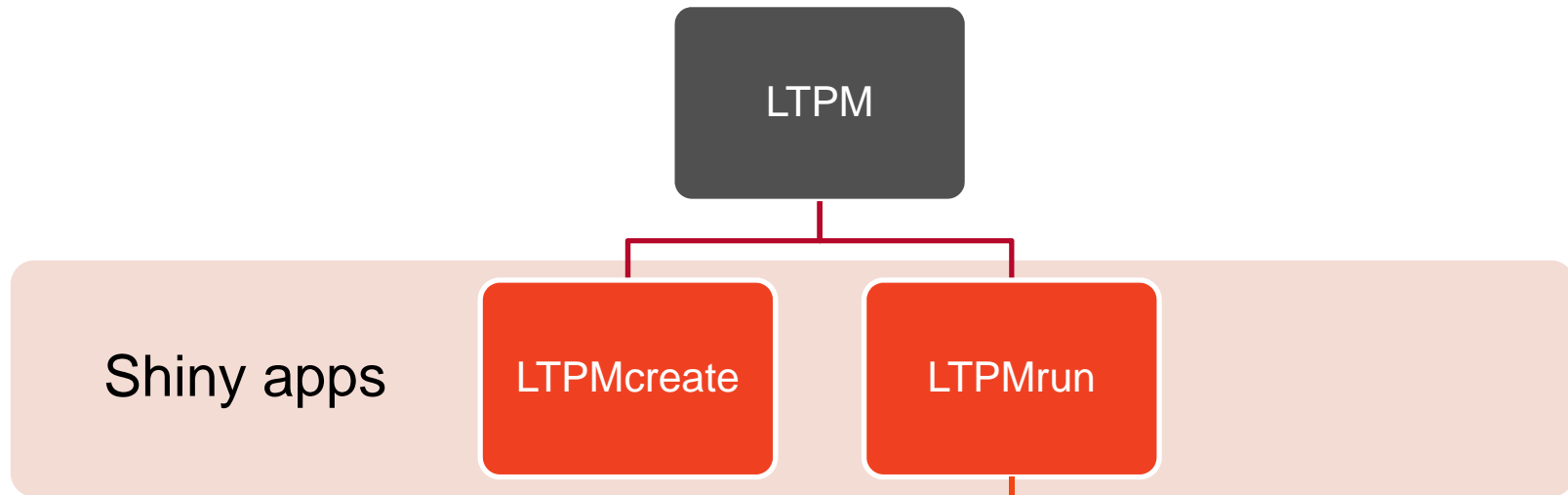
LTPM

PartnerRe





# GitLab repository





## R packages

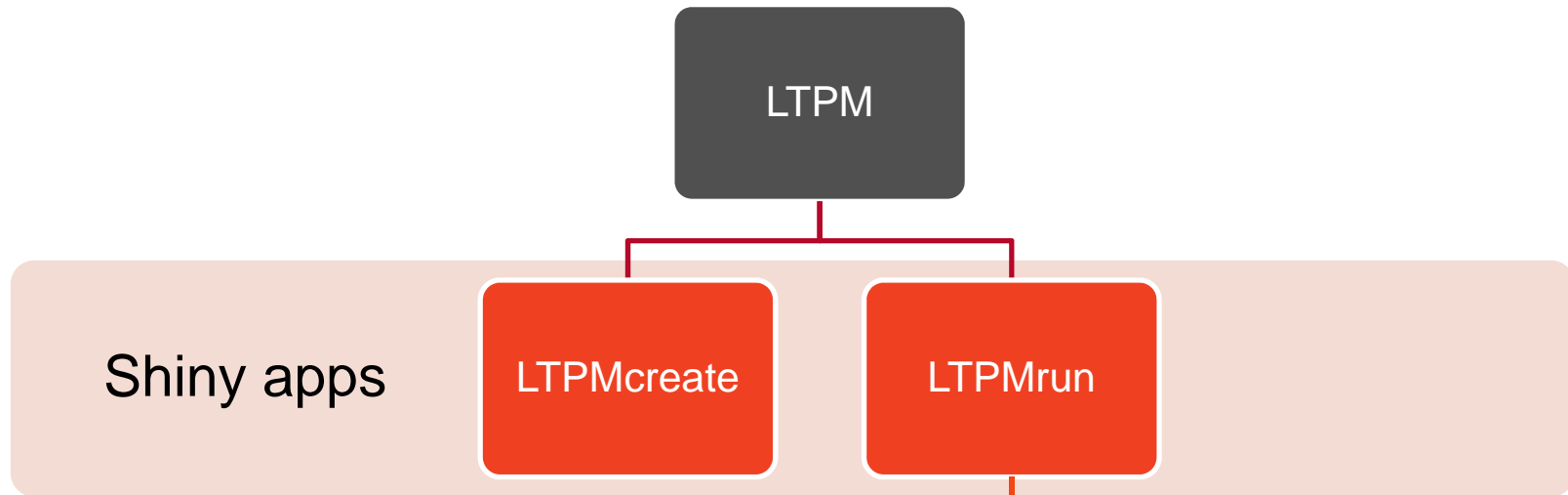
To support the calculations we have created three R extension packages:

1. **LTPMcalc**: includes all functionality for the actual calculations for the multi-state model.
2. **LTPMinput**: functionality to convert user input (i.e. spreadsheets) to an intermediate format (i.e. CSV).
3. **LTPMlogging**: functionality to allow all scripts and applications to log time-stamped information to the console or to a file on disk.





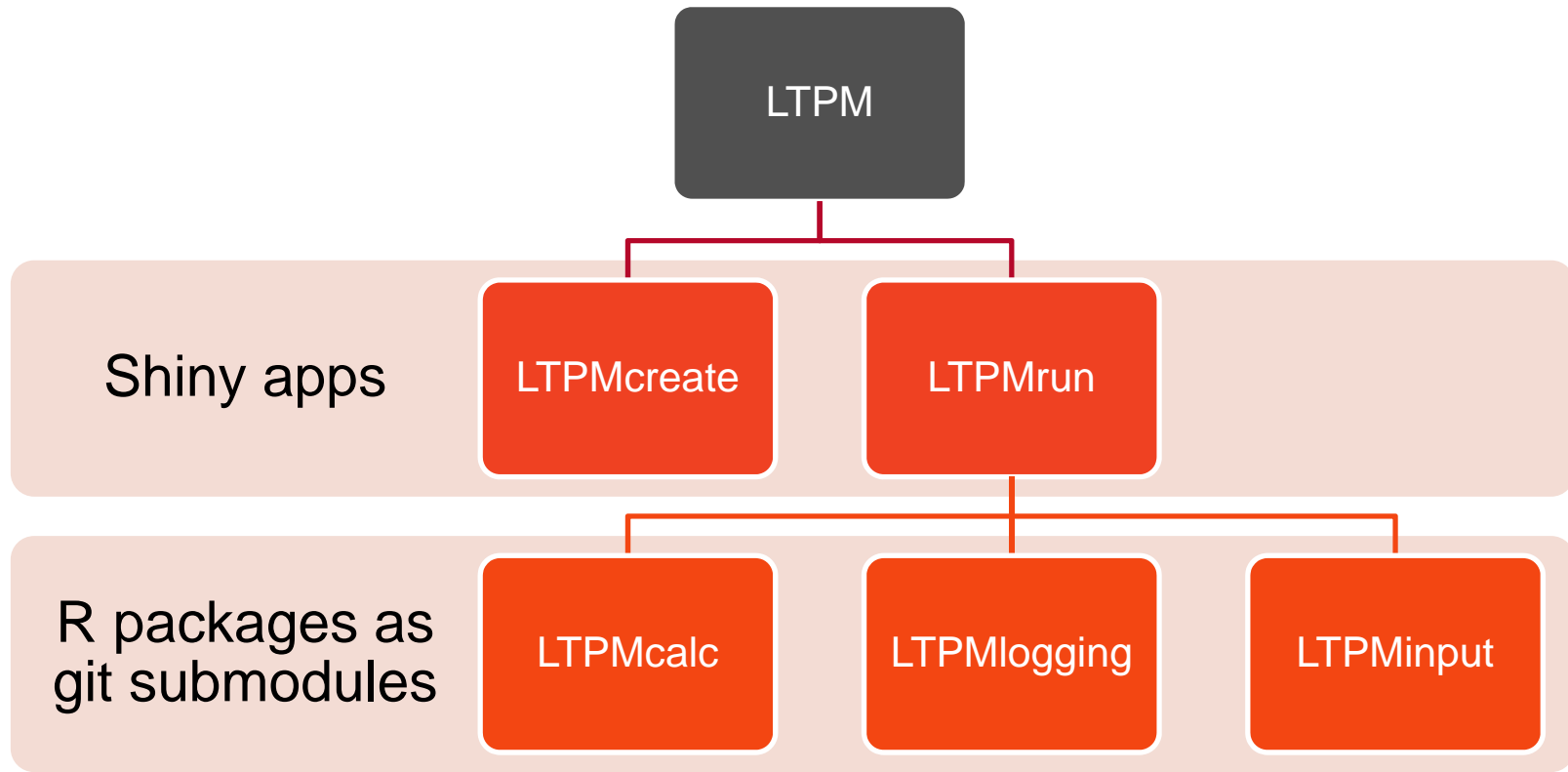
# GitLab repository







# GitLab repository



GitLab group

GitLab project

PartnerRe





## Packages as git submodules – GitLab view

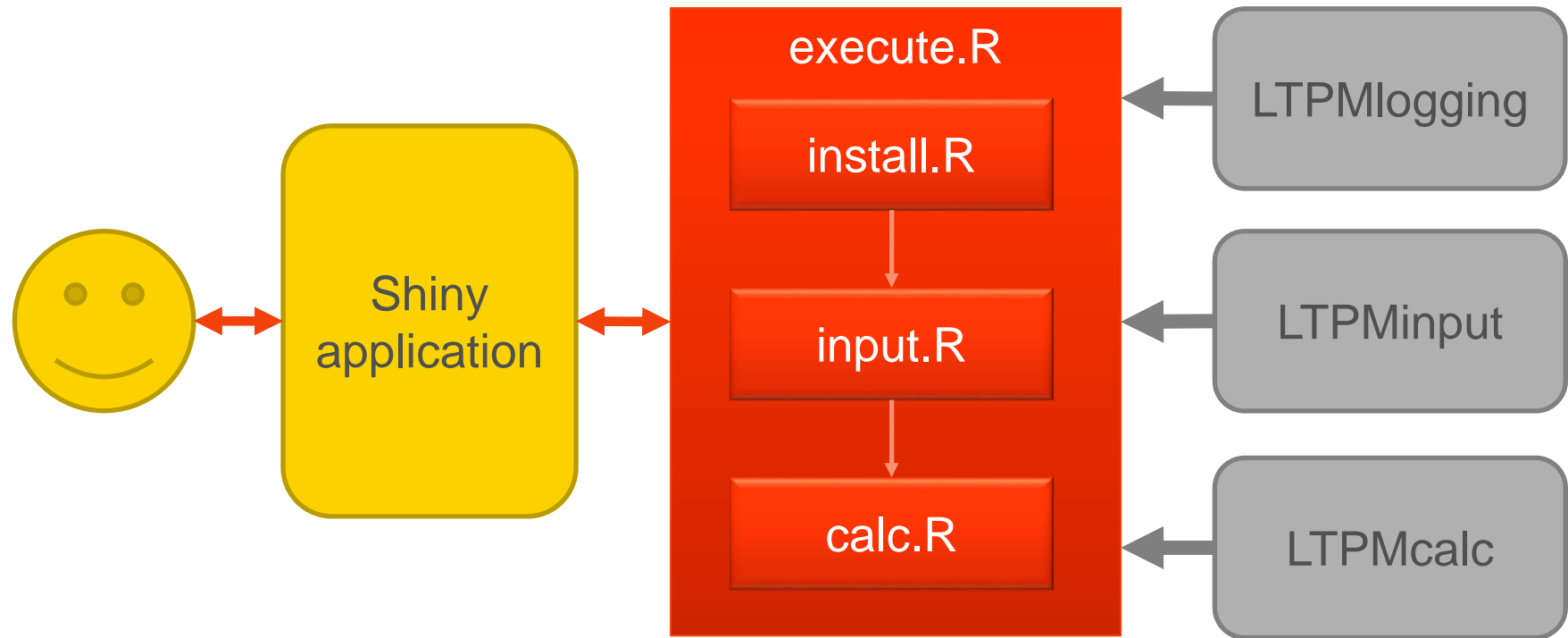
The screenshot shows the GitLab interface for a repository. The breadcrumb navigation at the top indicates the path: LTPM > LTPMrun > **Repository**. Below this, the current branch is 'master' and the file path is 'LTPMrun / src /'. A commit history entry is visible: 'Update LTPMcalc module' by Maarten-Jan Kallen, committed 3 days ago, with commit ID 3f292807. Below the commit history is a table of submodules:

Name	Last commit	Last update
..		
<b>LTPMcalc @ beFdd5fe</b>		
LTPMinput @ 7452f6b5		
LTPMlogging @ Fc984e68		





# Anatomy of LTPMrun



PartnerRe





## Executable R scripts

The *LTPMrun* application has one R script to execute a full calculation run called **execute.R**.

This script defines three execution steps, each implemented in a separate R script:

1. **install.R**: installation of R extension packages required by the run,
2. **input.R**: reading and conversion of input file(s) provided by the user,
3. **calc.R**: perform the calculations.





## LTPMcalc

The R package which implements the actual model functionality including the multi-state model.

The multi-state model is a Markov chain, which is a discrete-time Markov process.

Implementation details can be found in the package 'vignette'.

Markov chain for claim calculations in the LTPM

Maarten-Jan Kallen

May 8, 2017

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### 1 Introduction

This document is an attempt at formalizing the calculations of claims in the Long-Term Protection Model (LTPM) at PartnerRe. The goal of the model is to correctly price life insurance policies based on the expected claims from the insured. Pricing an insurance policy is notionally equivalent to calculating the size of the premium payments by the insured.





# Flexibility and adaptability

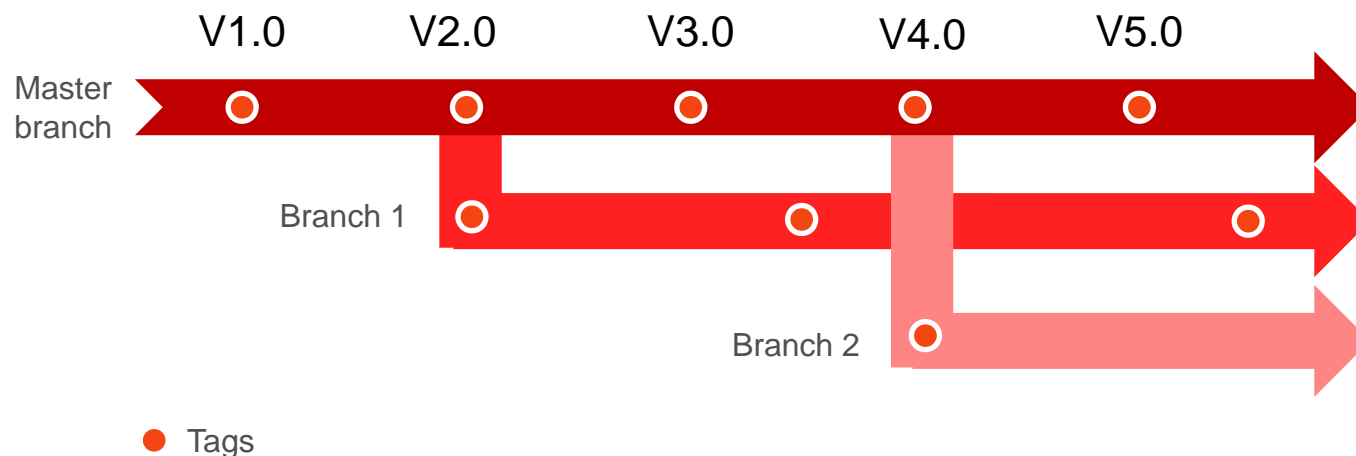




## Choice of actuarial model version

User can choose between:

- the latest released version
- past released versions
- customized version created by themselves
- customized version created by other user

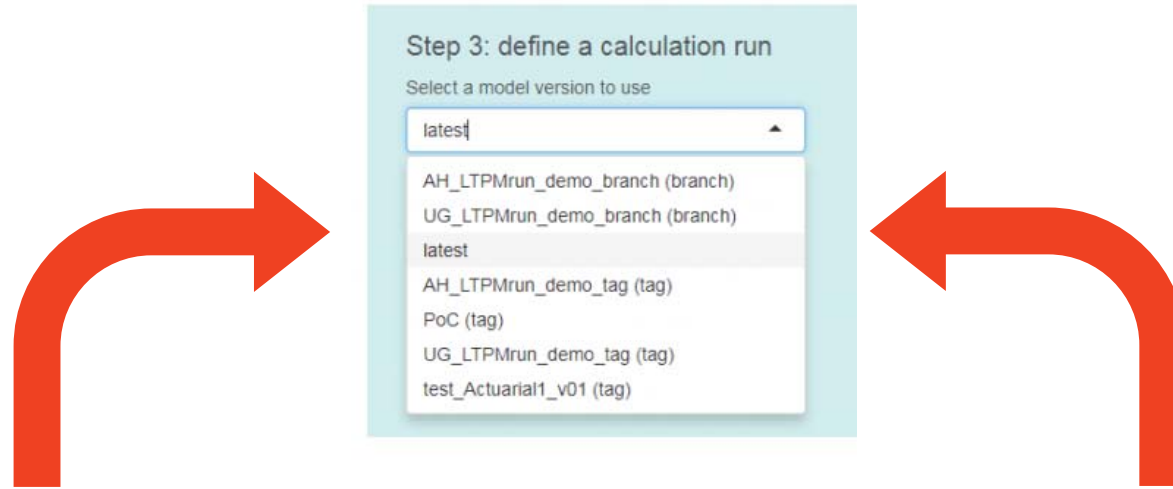


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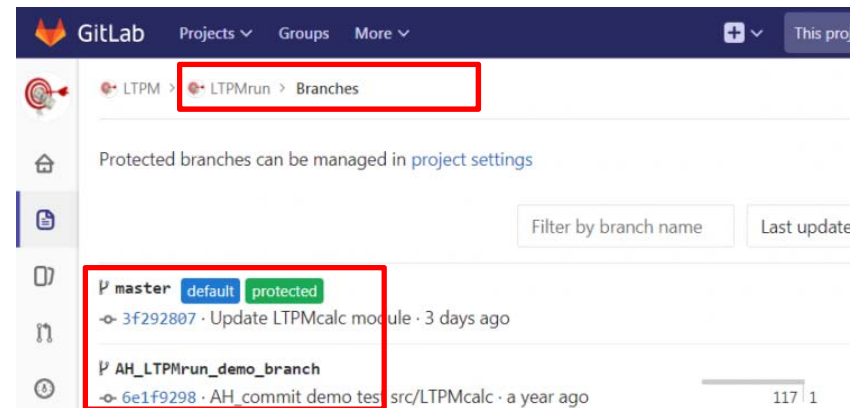
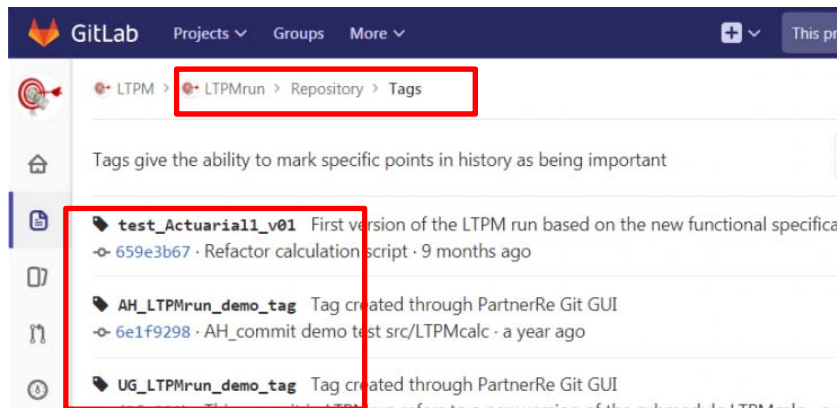


# Choice of actuarial model version



list of git tags

list of git branches







# Quality assurance





## How do we ensure that the model is correct?

We can never guarantee that the model is completely free of errors and bugs. To minimize errors, we apply standard practices for quality assurance in software development:

1. Many small unit tests for individual functions.
2. Integration (i.e. end-to-end) tests using pre-calculated results.
3. User testing.



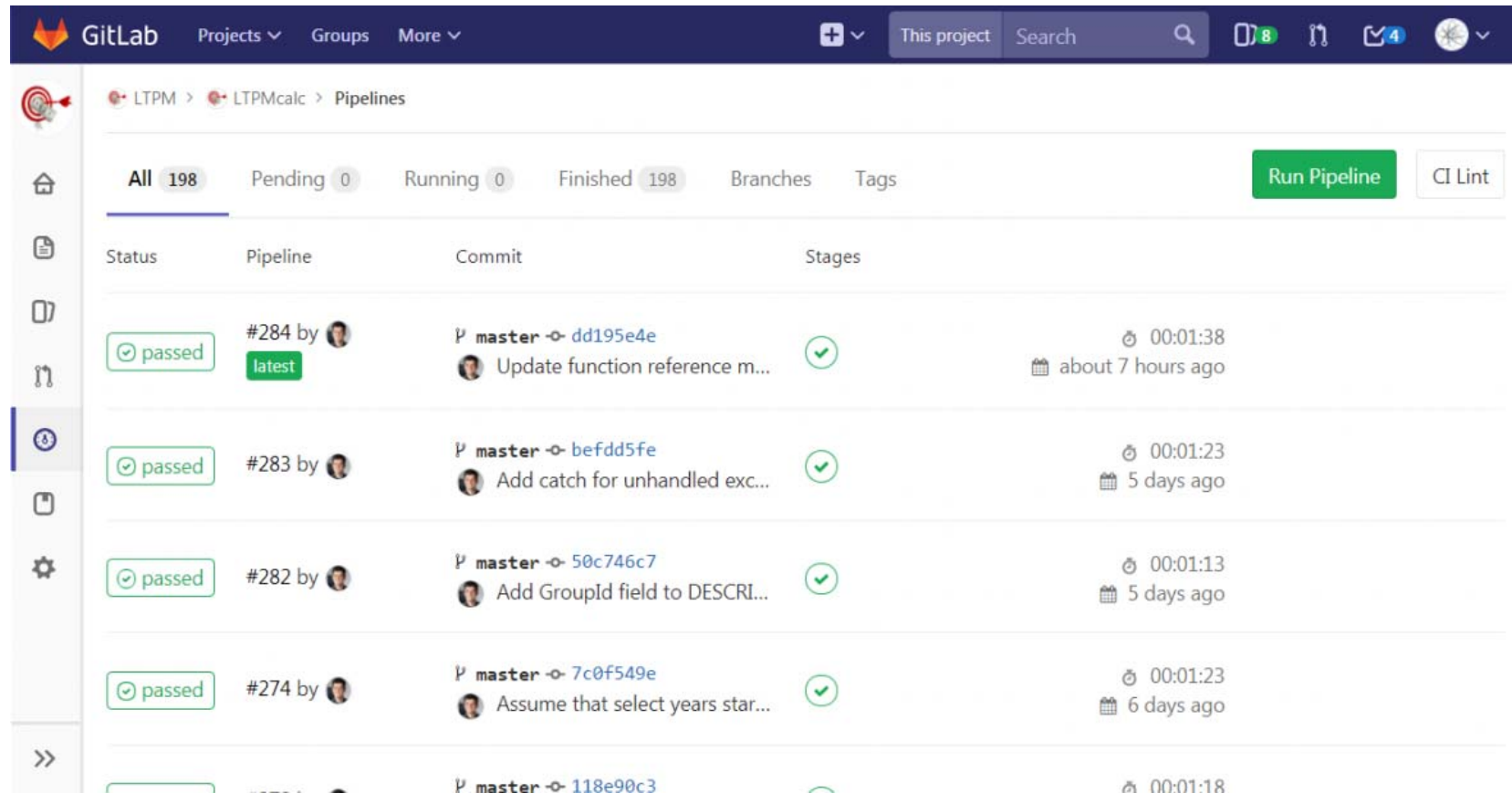


## GitLab

- **Source code version control using Git.**
- **Issue tracker to track bugs and our progress in fixing these.**
- **Continuous Integration (CI) ‘pipelines’ to automatically test –on the target system– all changes committed to the source code repository.**
  - performed in target environment
  - immediate upon push
  - notifications can be send to Slack



# GitLab - Continuous Integration



The screenshot displays the GitLab interface for a project named 'LTPM'. The 'Pipelines' section is active, showing a list of jobs. The top navigation bar includes 'GitLab', 'Projects', 'Groups', and 'More'. The main content area shows a table of pipeline jobs with columns for Status, Pipeline, Commit, and Stages. The jobs listed are all 'passed' and include commit hashes and descriptions.

Status	Pipeline	Commit	Stages
passed	#284 by [user] latest	master -> dd195e4e Update function reference m...	00:01:38 about 7 hours ago
passed	#283 by [user]	master -> befdd5fe Add catch for unhandled exc...	00:01:23 5 days ago
passed	#282 by [user]	master -> 50c746c7 Add GroupId field to DESCRI...	00:01:13 5 days ago
passed	#274 by [user]	master -> 7c0f549e Assume that select years star...	00:01:23 6 days ago
passed	[truncated]	master -> 118e90c3	00:01:18



# Questions?

