

# Package ‘critpath’

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**Type** Package

**Title** Setting the Critical Path in Project Management

**Version** 0.2.3

**Maintainer** Adam Kucharski <aqcharski@interia.pl>

## Description

Solving the problem of project management using CPM (Critical Path Method), PERT (Program Evaluation and Review Technique) and LESS (Least Cost Estimating and Scheduling) methods. The package sets the critical path, schedule and Gantt chart. In addition, it allows to draw a graph even with marked critical activities. For more information about project management see: Taha H. A. ``Operations Research. An Introduction" (2017, ISBN:978-1-292-16554-7), Rama Murthy P. ``Operations Research" (2007, ISBN:978-81-224-2944-2), Yuval Cohen & Arik Sadeh (2006) ``A New Approach for Constructing and Generating AOA Networks", Journal of Engineering, Computing and Architecture 1. 1-13, Konarzewska I., Jewczak M., Kucharski A. (2020, ISBN:978-83-8220-112-3), Miszczyńska D., Miszczyński M. ``Wybrane metody badań operacyjnych" (2000, ISBN:83-907712-0-9).

**License** GPL-2

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**Imports** DiagrammeR, ggplot2, reshape2, dplyr, stringr

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**Author** Adam Kucharski [aut, cre]

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cpmexample1

*Dataset for the CPM method*

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### Description

Fictitious data that is used in the examples. 6 activities, 5 nodes. In this dataset, the activities occur on the edges.

### Usage

cpmexample1

### Format

A data frame composed of predetermined columns:

**from** starting activity node

**to** final activity node

**label** activity label

**time** duration of the activity

---

cpmexample2

*Dataset for the CPM method*

---

### Description

Example from Miszczyńska D., Miszczyński M. "Wybrane metody badań operacyjnych" (2000, ISBN:83-907712-0-9). 10 activities, 8 nodes. In this dataset, the activities occur on the edges and a list of direct predecessors has been added.

### Usage

cpmexample2

### Format

A data frame composed of predetermined columns:

**label** activity label

**pred** preceding activities

**time** duration of the activity

---

lessexample1

*Dataset for the LESS method*

---

### Description

Fictitious data that is used in the examples. 6 activities, 5 nodes. In this dataset, the activities occur on the edges

### Usage

lessexample1

### Format

A data frame composed of predetermined columns:

**from** starting activity node

**to** final activity node

**label** activity label

**time** normal duration of the activity

**bound\_time** the shortest duration of the activity

**norm\_cost** normal cost of the activity

**bound\_cost** boundary cost of the activity

---

 lessexample2

*Dataset for the LESS method*


---

### Description

Example from Miszczyńska D., Miszczyński M. "Wybrane metody badań operacyjnych" (2000, ISBN:83-907712-0-9). In this dataset, the activities occur on the edges and a list of direct predecessors has been added.

### Usage

lessexample2

### Format

A data frame composed of predetermined columns:

**label** activity label

**pred** preceding activities

**time** normal duration of the activity

**bound\_time** the shortest duration of the activity

**norm\_cost** normal cost of the activity

**bound\_cost** boundary cost of the activity

---

 pertexample1

*Dataset for the PERT method*


---

### Description

Fictitious data that is used in the examples. 9 activities, 8 nodes. In this dataset, the activities occur on the edges

### Usage

pertexample1

### Format

A data frame composed of predetermined columns:

**from** starting activity node

**to** final activity node

**label** activity label

**opt\_time** optimistic duration of activity

**likely\_time** the most likely duration of the activity

**pes\_time** pesimistic duration of activity

---

pertexample2                      *Dataset for the PERT method*

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### Description

Example from Miszczyńska D., Miszczyński M. "Wybrane metody badań operacyjnych" (2000, ISBN:83-907712-0-9). 10 activities, 8 nodes. In this dataset, the activities occur on the edges and a list of direct predecessors has been added.

### Usage

```
pertexample2
```

### Format

A data frame composed of predetermined columns:

**label** activity label  
**pred** preceding activities  
**opt\_time** optimistic duration of activity  
**likely\_time** the most likely duration of the activity  
**pes\_time** pesimistic duration of activity

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PERT\_newprob                      *Probability for the given directive term*

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### Description

Probability for the given directive term

### Usage

```
PERT_newprob(new_DT, yourlist)
```

### Arguments

**new\_DT**                      The given project completion date. The parameter must be greater than zero.  
**yourlist**                      List of objects that make up the solution to the project management problem.

### Value

This function calculates the probability of completing the project within the time specified by the user. A normal distribution was assumed.

### Examples

```
y <- solve_pathAOA(pertexample1, deterministic = FALSE)
PERT_newprob(new_DT = 30, y)
```

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PERT_newtime	<i>A new directive term for any probability</i>
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**Description**

A new directive term for any probability

**Usage**

```
PERT_newtime(new_prob = 0.5, yourlist)
```

**Arguments**

new_prob	Probability of the project completion. Default set to 0.5.
yourlist	List of objects that make up the solution to the project management problem.

**Value**

This function computes a new directive term for a probability given by the user. A normal distribution was assumed.

**Examples**

```
y <- solve_pathAOA(pertexample1, deterministic = FALSE)
PERT_newtime(new_prob = 0.3, y)
```

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plot_alap	<i>An ALAP chart</i>
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**Description**

An ALAP chart

**Usage**

```
plot_alap(yourlist, show_dummy = FALSE, bar_size = 10)
```

**Arguments**

yourlist	List of objects that make up the solution to the project management problem.
show_dummy	Decides whether dummy activities should be included in the chart. If so, set it to TRUE (set to FALSE by default).
bar_size	Thickness of the bar drawn for activity (set to 10 by default).

**Value**

Draws an ALAP (activities start and finish As Late As Possible) chart broken down into critical ("CR") and non-critical ("NC") activities. Marks total float.

**Examples**

```
x <- solve_pathAOA(cpmexample1, deterministic = TRUE)
plot_alap(x)
```

---

plot_asap	<i>An ASAP chart</i>
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---

**Description**

An ASAP chart

**Usage**

```
plot_asap(yourlist, show_dummy = FALSE, bar_size = 10)
```

**Arguments**

yourlist	List of objects that make up the solution to the project management problem.
show_dummy	Decides whether dummy activities should be included in the chart. If so, set it to TRUE (set to FALSE by default).
bar_size	Thickness of the bar drawn for activity (set to 10 by default).

**Value**

Draws an ASAP (activities start and finish As Soon As Possible) chart broken down into critical ("CR") and non-critical ("NC") activities. Marks total floats.

**Examples**

```
x <- solve_pathAOA(cpmexample1, deterministic = TRUE)
plot_asap(x)
```

---

plot_gantt	<i>A Gantt chart</i>
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**Description**

A Gantt chart

**Usage**

```
plot_gantt(yourlist, show_dummy = FALSE, bar_size = 10)
```

**Arguments**

yourlist	List of objects that make up the solution to the project management problem.
show_dummy	Decides whether dummy activities should be included in the chart. If so, set it to TRUE (set to FALSE by default).
bar_size	Thickness of the bar drawn for activity (set to 10 by default).

**Value**

Draws a Gantt chart broken down into critical ("CR") and non-critical ("NC") activities. Marks total floats.

**Examples**

```
x <- solve_pathAOA(cpmexample1, deterministic = TRUE)
plot_gantt(x)
```

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plot_graphAOA	<i>A graph of connections between nodes</i>
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**Description**

A graph of connections between nodes

**Usage**

```
plot_graphAOA(input_data, predecessors = FALSE, solved = NULL, fixed_seed = 23)
```

**Arguments**

input_data	Data frame describing the problem.
predecessors	TRUE if the user data contains a list of immediately preceding activities
solved	List of objects that make up the solution to the project management problem.
fixed_seed	Optional parameter setting random seed to user value to get similar looking plots each time the function is run (set to 23 by default).

**Value**

The function draws a graph showing dependencies between nodes. The "solved" parameter determines whether there is a critical path in the graph. In that case, you must solve the problem first. In the examples below, the function first draws the graph only on the basis of the data frame and then after determining the critical path.

**Examples**

```
plot_graphAOA(cpmexample1)
x <- solve_pathAOA(cpmexample1, TRUE)
plot_graphAOA(solved = x)
```

---

plot\_norm

*The cumulative distribution function of the normal distribution*

---

**Description**

The cumulative distribution function of the normal distribution

**Usage**

```
plot_norm(yourlist)
```

**Arguments**

`yourlist` List of objects making up the solution to the project management problem

**Value**

Draws a graph of the normal distribution with the expected directive term from the PERT method and the standard deviation for this term. The chart also includes lines indicating the schedules of the risk-taker and the belayer.

**Examples**

```
y <- solve_pathAOA(pertexample1, deterministic = FALSE)
plot_norm(y)
```

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plot_TC	<i>Total cost change plot</i>
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**Description**

Total cost change plot

**Usage**

```
plot_TC(your_list)
```

**Arguments**

your\_list      List containing solved problem

**Value**

Based on the results of the LESS method, a graph of the total cost value of all iterations is created

**Examples**

```
z <- solve_lessAOA(lessexample1, 50, 15)
plot_TC(z)
```

---

solve_lessAOA	<i>Determines the solution using the LESS method. Relationships between activities can be given as a list of predecessors or start and end node numbers.</i>
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---

**Description**

Determines the solution using the LESS method. Relationships between activities can be given as a list of predecessors or start and end node numbers.

**Usage**

```
solve_lessAOA(input_data, ICconst, ICslope, predecessors = FALSE)
```

**Arguments**

input\_data      Data frame containing the graph structure and activity durations. For the LESS method and start/end nodes you need 7 columns (the order matters):

1. from The number of the node where the activity starts.
2. to The number of the node where the activity ends.
3. label Activity labels.
4. time Normal duration of activities.

5. `crash_time` Crash (the shortest possible) duration of activities.
6. `norm_cost` Normal costs.
7. `crash_cost` Crash costs.

For the LESS method and predecessors list you need 6 columns (the order matters):

1. `label` Activity labels.
2. `pred` List of predecessors.
3. `time` Normal duration of activities.
4. `crash_time` Crash (the shortest possible) duration of activities.
5. `norm_cost` Normal costs.
6. `crash_cost` Crash costs.

<code>ICconst</code>	Intercept of the indirect cost function.
<code>ICslope</code>	Slope of the indirect cost function.
<code>predecessors</code>	TRUE if the user data contains a list of immediately preceding activities If set to FALSE (default), start and end nodes are used. If is set to TRUE, predecessors list is used.

### Value

A list made of a graph and a result set.

### Examples

```
z <- solve_lessAOA(lessexample1, 50, 15)
```

---

<code>solve_pathAOA</code>	<i>Finds a solution using CPM and PERT methods. Relationships between activities can be given as a list of predecessors or start and end node numbers.</i>
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### Description

Finds a solution using CPM and PERT methods. Relationships between activities can be given as a list of predecessors or start and end node numbers.

### Usage

```
solve_pathAOA(
  input_data,
  deterministic = TRUE,
  predecessors = FALSE,
  pert_param = 0
)
```

**Arguments**

input_data	<p>Data frame containing the structure of the graph and the duration of the activity. For the CPM method and start/end nodes you need 4 columns (the order is important, not the name of the column):</p> <ol style="list-style-type: none"> <li>1. from The number of the node where the activity starts.</li> <li>2. to The number of the node where the activity ends.</li> <li>3. label Activity labels.</li> <li>4. time Activities durations.</li> </ol> <p>For the CPM method and predecessors list you need 3 columns (the order is important, not the name of the column):</p> <ol style="list-style-type: none"> <li>1. label Activity labels.</li> <li>2. pred List of predecessors.</li> <li>3. time Activities durations.</li> </ol> <p>For the PERT method and start/end nodes you need 6 columns (the order is important, not the name of the column):</p> <ol style="list-style-type: none"> <li>1. from The number of the node where the activity starts.</li> <li>2. to The number of the node where the activity ends.</li> <li>3. label Activity labels.</li> <li>4. opt_time Optimistic duration of activities.</li> <li>5. likely_time The most likely duration of the activity.</li> <li>6. pes_time Pessimistic duration of activities.</li> </ol> <p>For the PERT method and predecessors list you need 5 columns (the order is important, not the name of the column):</p> <ol style="list-style-type: none"> <li>1. label Activity labels.</li> <li>2. pred List of predecessors.</li> <li>3. opt_time Optimistic duration of activities.</li> <li>4. likely_time The most likely duration of the activity.</li> <li>5. pes_time Pessimistic duration of activities.</li> </ol>
deterministic	A logical parameter specifying the solution method. If set to TRUE (default), the CPM method is used. If is set to FALSE, the PERT method is used.
predecessors	TRUE if the user data contains a list of immediately preceding activities If set to FALSE (default), start nad end nodes are used. If is set to TRUE, predecessors list is used.
pert_param	A parameter that controls the method of calculating the expected value and variance in the PERT method. 0 - classic formula (default), 1 - 1st and 99th percentile of the beta distribution, 2 - 5th and 95th percentile of the beta distribution, 3 - 5th and 95th percentiles of the beta distribution with modification by (Perry and Greig, 1975), 4 - Extended Pearson's and Tukey's formula (Pearson and Tukey, 1965), 5 - Golenko-Ginzburg's full formula (Golenko-Ginzburg, 1988), 6 - Golenko-Ginzburg's reduced formula (Golenko-Ginzburg, 1988), 7 - Farnum's and Stanton's formula (Farnum and Stanton, 1987).

**Value**

The list is made of a graph, schedule and selected partial results.

**Examples**

```
x <- solve_pathAOA(cpmexample1, deterministic = TRUE)
y <- solve_pathAOA(pertexample1, deterministic = FALSE)
x <- solve_pathAOA(cpmexample2, deterministic = TRUE, predecessors = TRUE)
y <- solve_pathAOA(pertexample2, deterministic = FALSE, predecessors = TRUE)
```

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