Time Petri Nets: Theory, Tools and Applications

Part III

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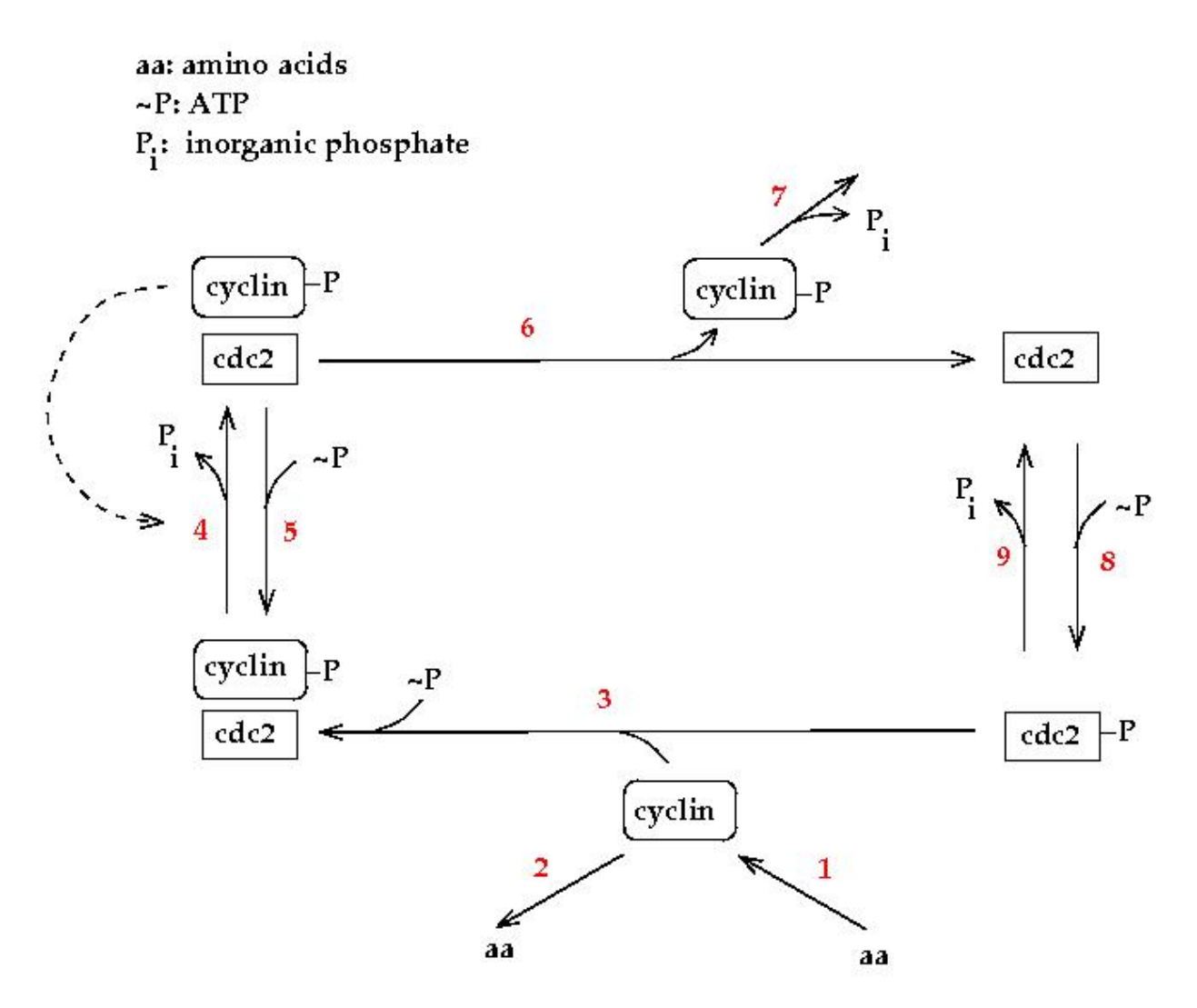
ATPN 2008, Xi'an, China

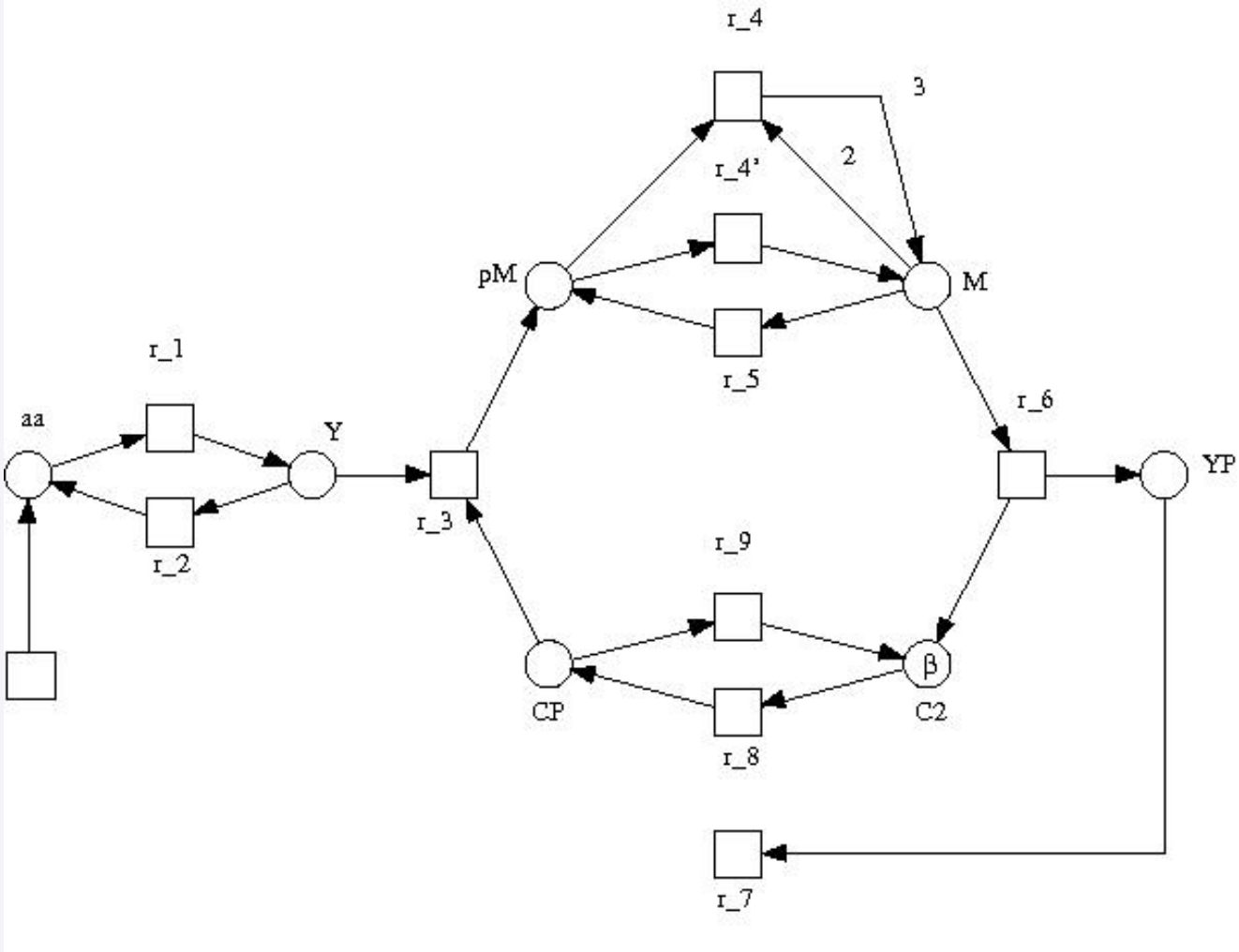
Outline

The relationship between cyclin and cdc2 in the cell cycle



The relationship between cyclin and cdc2 in the cell cycle as a DIPN

A PN model of the continuous system:



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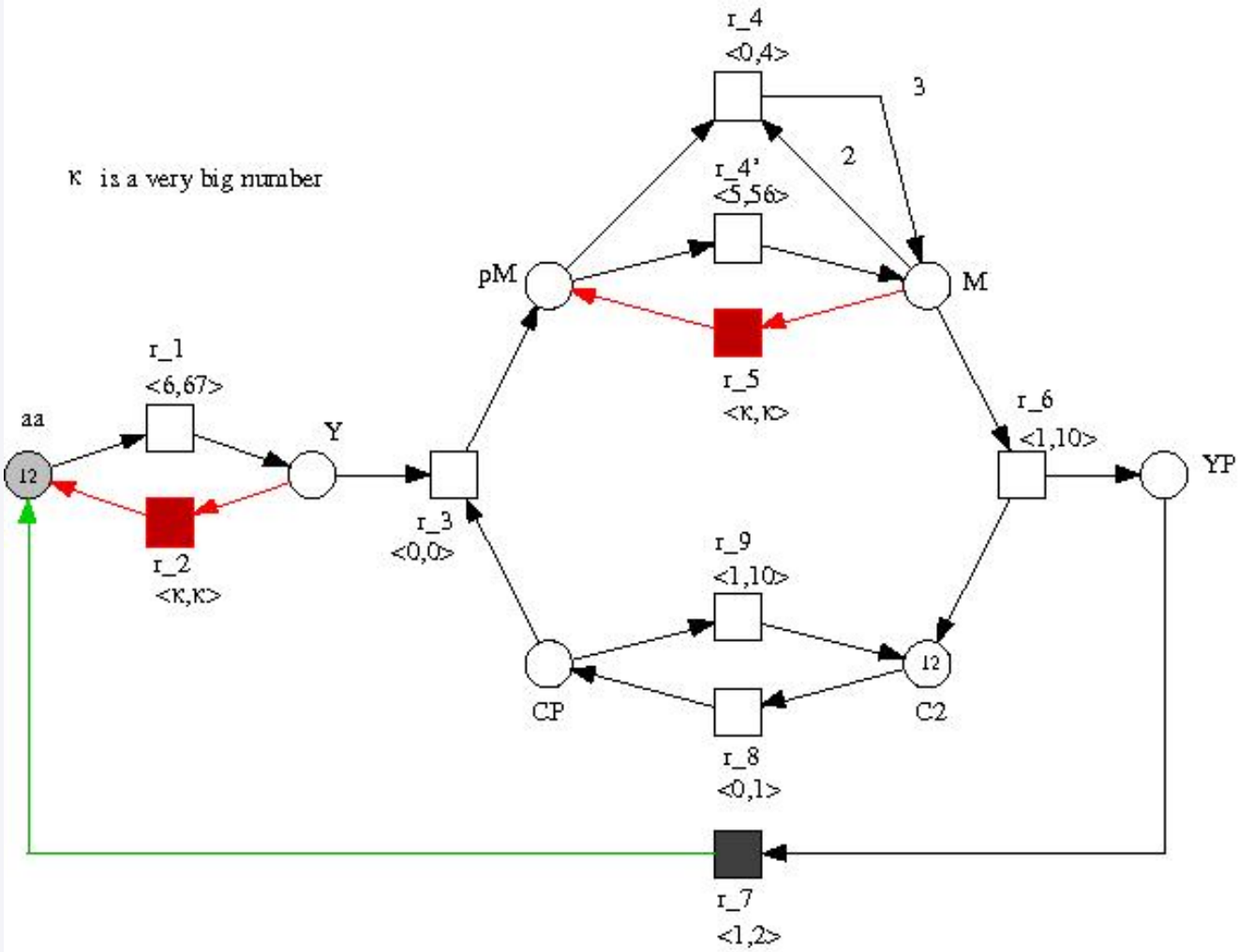
- The time dependent model of the system is a **DIPN (Duration Interval Peiri Net)**

The relationship between cyclin and cdc2 in the cell cycle as a DIPN

A DIPN model as a momentary snapshot of the continuous system:



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And:

- The minimal time distance between the initial state and an arbirary state in which k_4 is ready to fire is 74; Proved with INA

  Thus, the minimal time for starting the dephosphorylation of the cdc2 in order to form active MPF modelled with k_4 is not less than 74 minutes.

Graphical Net Editor

Snoopy: a tool to design (and animate timeless) graph-based formalisms for Linux, Windows, Mac

(http://www-dssz.informatik.tu-cottbus.de/software/snoopy.html)

- place/transition Petri net
- extended Petri net (read / inhibitor / reset arcs)
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Net Editor

Snoopy can export datas (files) to several tools:

- INA
- TINA
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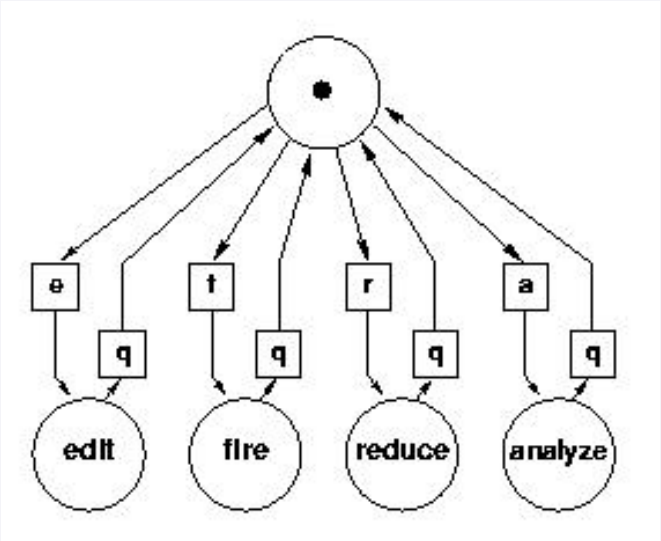
Petri Net Analyzer

INA
Integrated Net Analyzer

(http://http://www2.informatik.hu-berlin.de/∼starke/ina.html)



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  - analyze classical PN, colored PN, Time PN, Timed PN, (PN with timed arcs) for:
    - qualitative properties: statically and dynamically (s. next slide)
    - some quantitative properties:
      - time length of a run,
      - shortest and longest (time) distance between states/p-markings in bounded (timedependent) PN, etc.

INA - A Short Introduction

Current net options are:

token type: black (for Place/Transition nets)
time option: no times
firing rule: normal
priorities: not to be used
strategy: single transitions
line length: 80

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Current net options are:

token type: coloured (for Coloured Petri nets)
time option: no times
firing rule: normal
priorities: not to be used
strategy: single transitions
line length: 80

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Current net options are:

token type: black (for Place/Transition nets)
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Current net options are:

token type: black (for Place/Transition nets)
time option: durations
firing rule: normal
priorities: not to be used
strategy: single transitions
line length: 80

INA - A Short Introduction

Current net options are:

token type: black (for Place/Transition nets)
time option: intervals
firing rule: normal
priorities: not to be used
strategy: single transitions
line length: 80

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token type: black (for Place/Transition nets)
time option: no times
firing rule: normal
priorities: not to be used
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line length: 80

INA - A Short Introduction

Current net options are:

token type: black (for Place/Transition nets)
time option: no times
firing rule: normal with capacities
priorities: not to be used
strategy: single transitions
line length: 80

INA - A Short Introduction

Current net options are:

token type: black (for Place/Transition nets)
time option: no times
firing rule: save
priorities: not to be used
strategy: single transitions
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time option: no times
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time option: no times
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INA - A Short Introduction

Do You want to

edit ? ..... E
fire ? ..... F
analyse ? ..... A
reduce ? ..... R
read the session report ? ..... S
delete the session report ? ..... D
change options ? ..... O
quit ? ..... Q

INA - A Short Introduction

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quit ? ..... Q

Petri net input file > tyson-without-time.pnt

:

Information on elementary structural properties:

The tyson-without-time PN is:

The net is not statically conflict-free.
The net is pure.
The net is not ordinary.
The net is not conservative.
The net is not subconservative.
The net is not a state machine.
The net is not free choice.
The net is not extended free choice.
The net is not extended simple.
The net is not safe.
The net is not live and safe.
The net is marked.
The net is not marked with exactly one token.
The net is not a marked graph.
The net is not homogenous.
The net has not a non-blocking multiplicity.
The net has no nonempty clean trap.
The net has no transitions without pre-place.
The net has no transitions without post-place.
The net has no places without pre-transition.
The net has no places without post-transition.
The net is connected.
The net is strongly connected.

Further Properties

- DTP: deadlock-trap-property
- SMC: state machine coverable
- SMD: state machine decomposable
- SMA: state machine allocatable
- CPI: covered by place invariants
- CTI: covered by transition invariants
- B : bounded
- SB : structurally bounded
- REV: reversible
- DSt: dead state reachable
- BSt: bad state reachable
- DTr: dead transition at initial marking
- DCF: dynamically conflict free
- L : live
- LV : live when ignoring dead transitions
- L&S: live and safe
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- WL : weakly live
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ORD	HOM	NBM	PUR	CSV	SCF	CON	SC	Ft0	tF0	Fp0	pF0	MG	SM	FC	EFC	ES
N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	N	N	N
CPI	CTI	B	SB	REV	DSt	BSt	DTr	DCF	L	LV	L&S					
Y	Y	Y	Y	N	N	?	Y	?	N	Y	N					

INA: Further Analyze

Analysis menu: Decide structural boundedness.....B
Non-reachability test of a partial marking using the state equation.....N
Compute the symmetries of the net.....Y

Compute a shortest path from the initial state to a target marking.....P
Compute a minimal path from the initial state to satisfy a predicate.....O
Compute a reachability graph.....R
Compute a coverability graph to decide boundedness and coverability.....G

Compute a basis for all P/T-invariants [non-reachability test].....I
Compute a basis for all semipositive P/T-[sub/sur]-invariants.....S
Format lines written to INVARI.HLP earlier.....F
Test place- or transition-vectors for invariant properties.....T

INA: Further Analyze

Graph analysis menue

quit analysis of the computed graph ..... Q

test the reachability/coverability of a marking ..... R
convert a set of states to a predicate C
define an enabledness predicate ..... E
check a CTL-formula ..... F
compute distances ..... A
compute circuits ..... K
check liveness properties L
compute strongly connected components V

write the computed graph (states and arcs) ..... W
write all arcs X
write all states ..... M
write all states satisfying a predicate ..... P
write a trace to a state ..... T
write the list of executed steps I

A Short Part of the Bibliography

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Popova-Zeugmann, L. and Werner, W. and Richling, J.

Using State-equation to Pove Non-reachability in Timed Petrinets.
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Journal of Control and Cybernetics, 35(3):721–748, 2007.

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Time and Petri Nets (in German).
Habilitation Thesis, Humboldt University at Berlin, Berlin, 2007.

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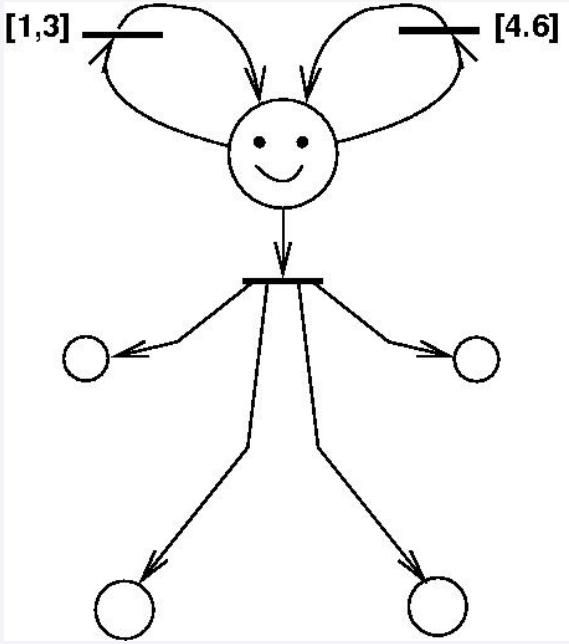
Quantitative Evaluation of Time Dependent Petri Nets and Applications to Biochemical Networks.
(to appear), 2008.

For more see:
http://http://www2.informatik.hu-berlin.de/∼starke/ina.html
http://http://www2.informatik.hu-berlin.de/∼popova

Thank you!



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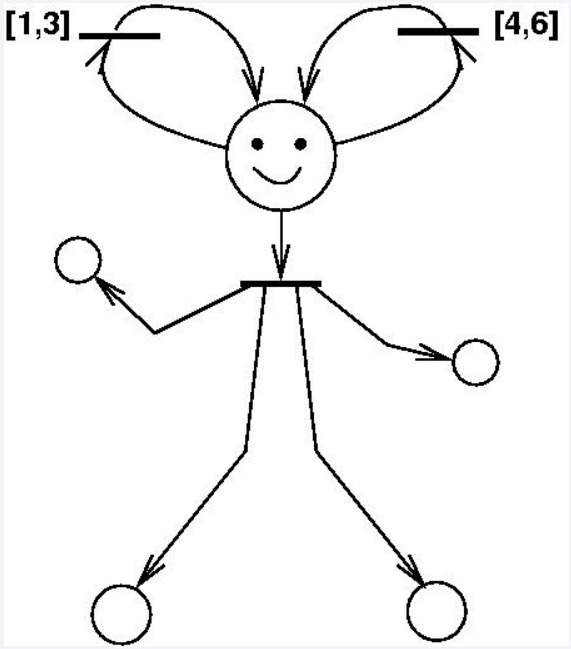

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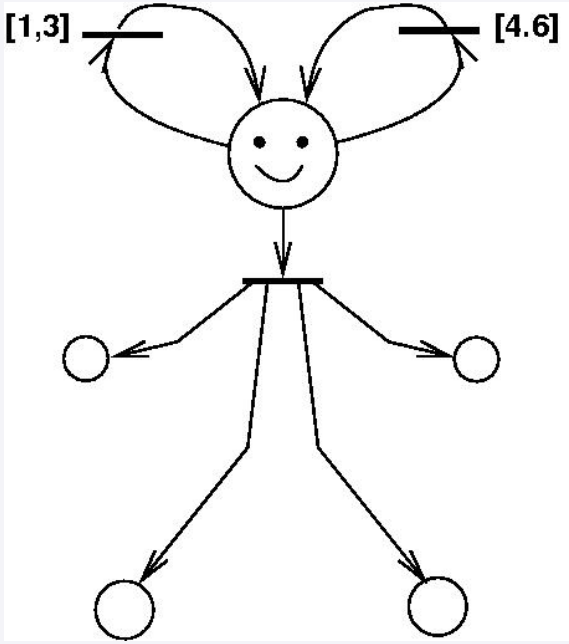

The relationship between cyclin and cdc2 in the cell cycle

In step 1, cyclin is synthesized *de novo*. Newly synthesized cyclin may be unstable (step 2). Cyclin combines with cdc2-P (step 3) to form pre-maturation promoting factor (preMPF). At some point after heterodimer formation, the cyclin subunit is phosphorylated. ... The cdc2 subunit is then dephosphorylated (step 4) to form active MPF. In principle, the activation of MPF may be opposed by protein kinase (step 5). Assuming that active MPF enhances the catalytic activity of the phosphatase, I arrange that MPF activation is switched on in an autocatalytic fashion. Nuclear division is triggered when a sufficient quantity of MPF has been activated, but concurrently active MPF is destroyed by step 6. Breakdown of the MPF complex releases phosphorylated cyclin, which is subject to rapid proteolysis (step 7). Finally, the cdc2 subunit is phosphorylated (step 8, possibly reversed by step 9), and the cycle repeats itself.

(Tyson, J., *"Modeling the cell division cycle: cdc2 and cyclin interactions"*, Prod.Nat.Acad.Sci. USA,Vol. 88, 1991)