

Model Checking Cancer Automata

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Outline

- What is **cancer**?
- How to model it?
- How to **extend/improve** the model?
- What are the **verification results**?
- **Conclusion** and **possible future works**



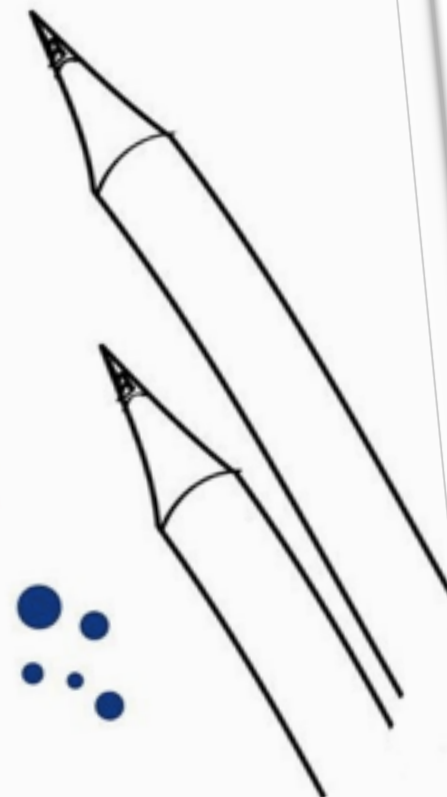
PLANNING

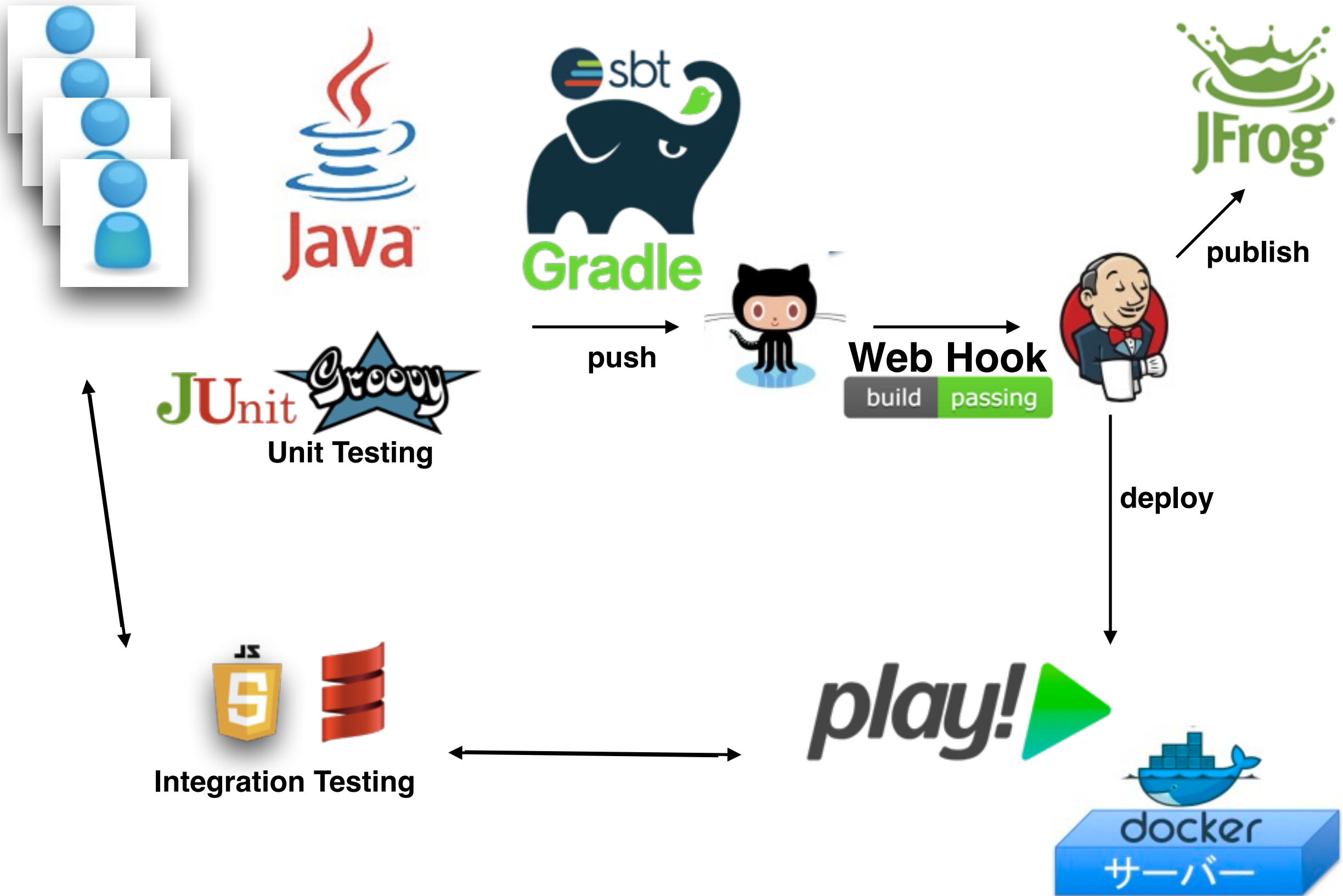
ANALYZE

DESIGN

SOFTWARE ENGINEERING

VALIDATION
AND VERIFICATION





Continuous Integration

Misc....



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Cancer as a system?

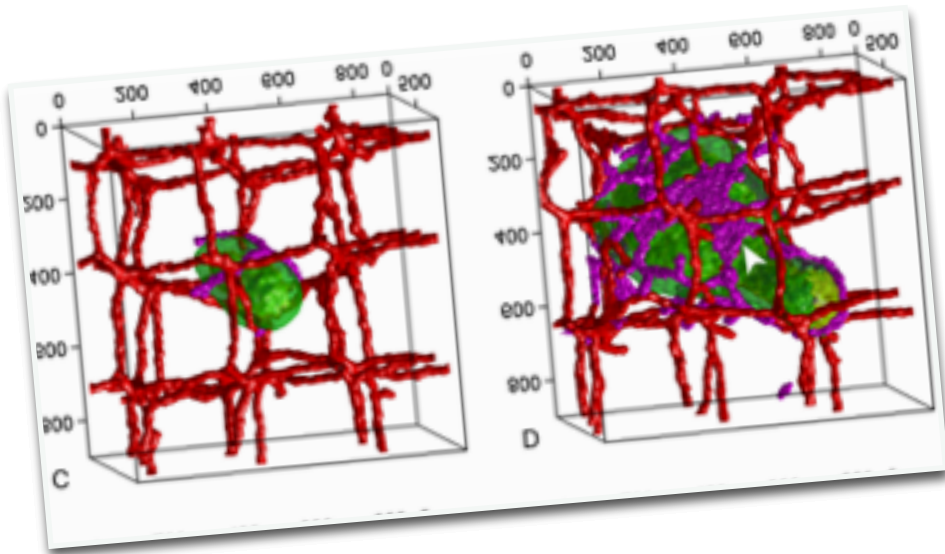
Cancer

is a progressive disease

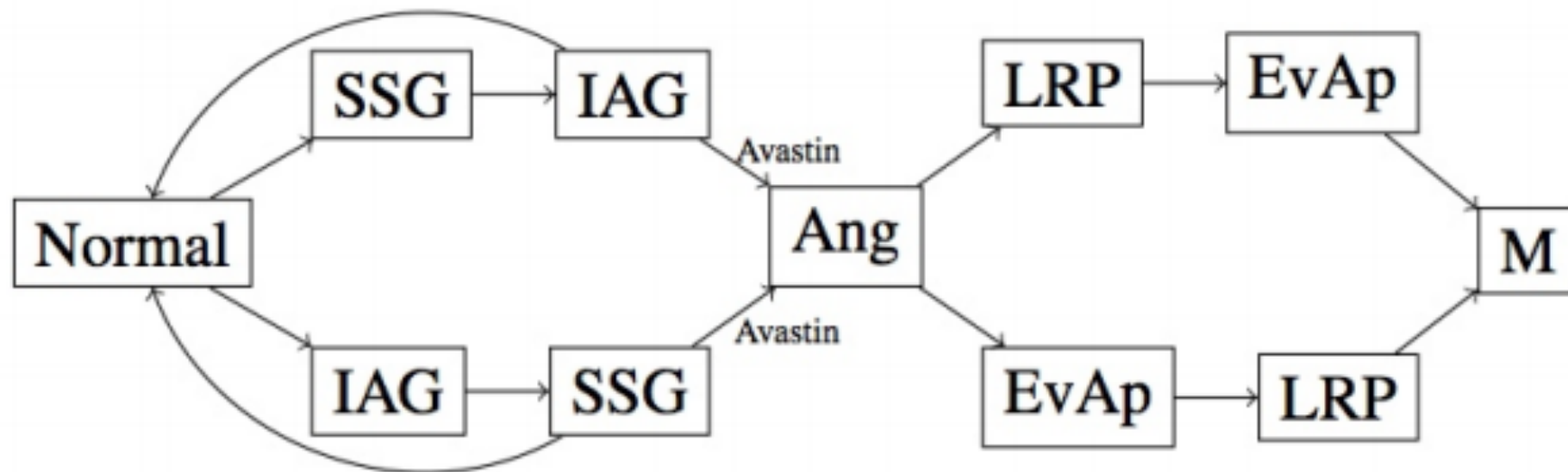
is a disease of all ages

**one of the most common cause
of death** in the US and Europe

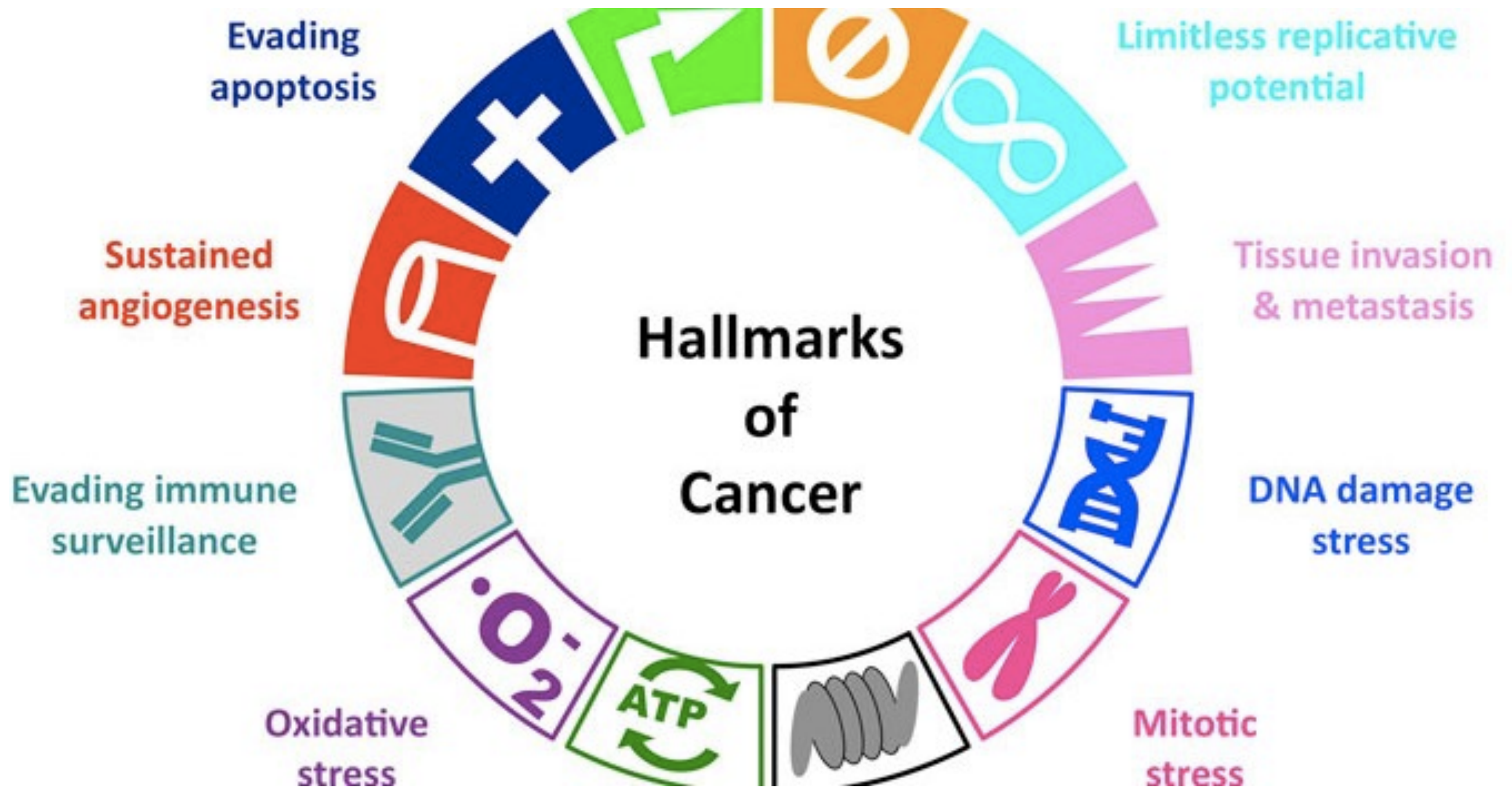
Cancer Models



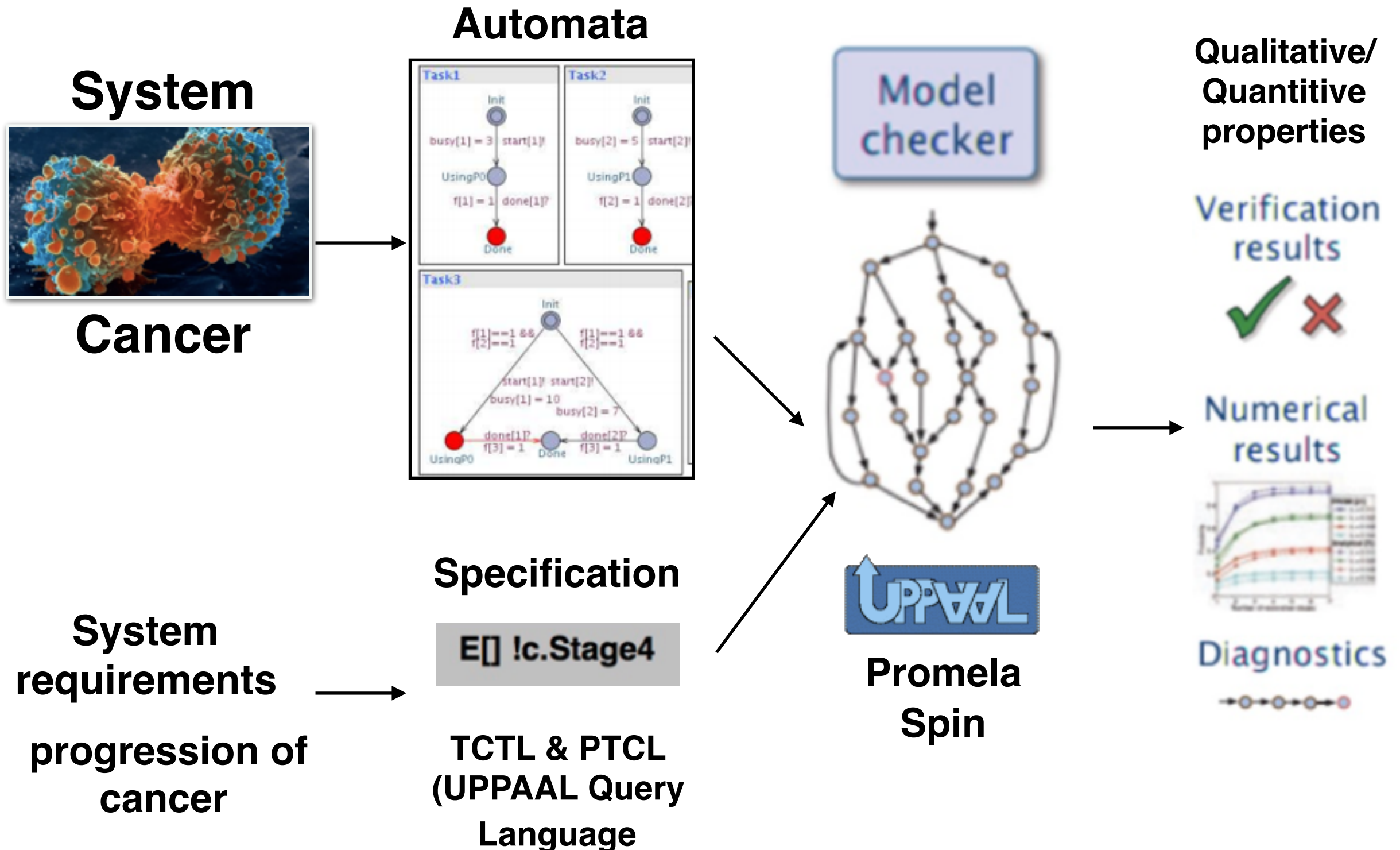
- ***Mathematical model***
- ***3D Simulation***



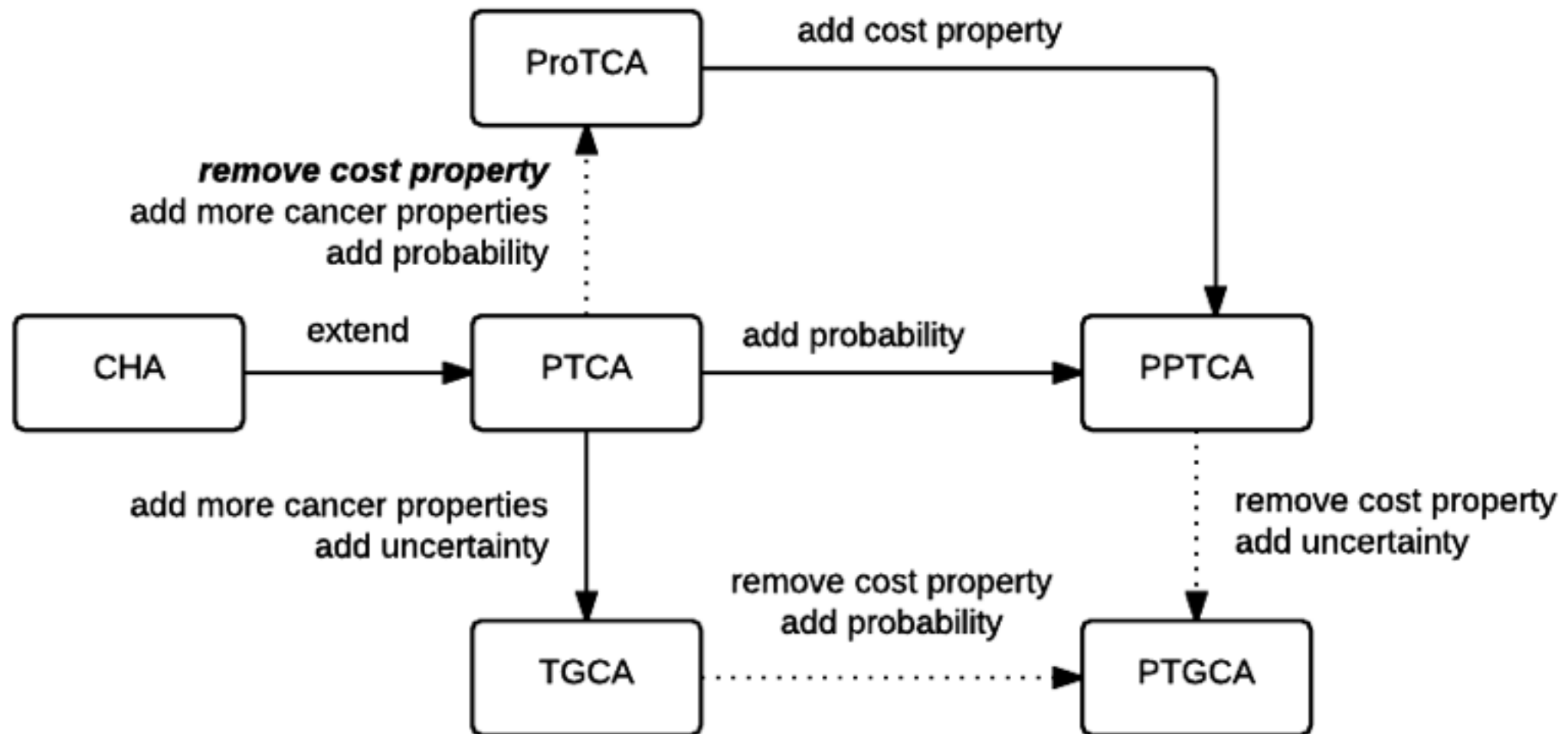
Cancer Hybrid automata



Cancer Models



Extending the model



Priced Timed Cancer Automata (PTCA)

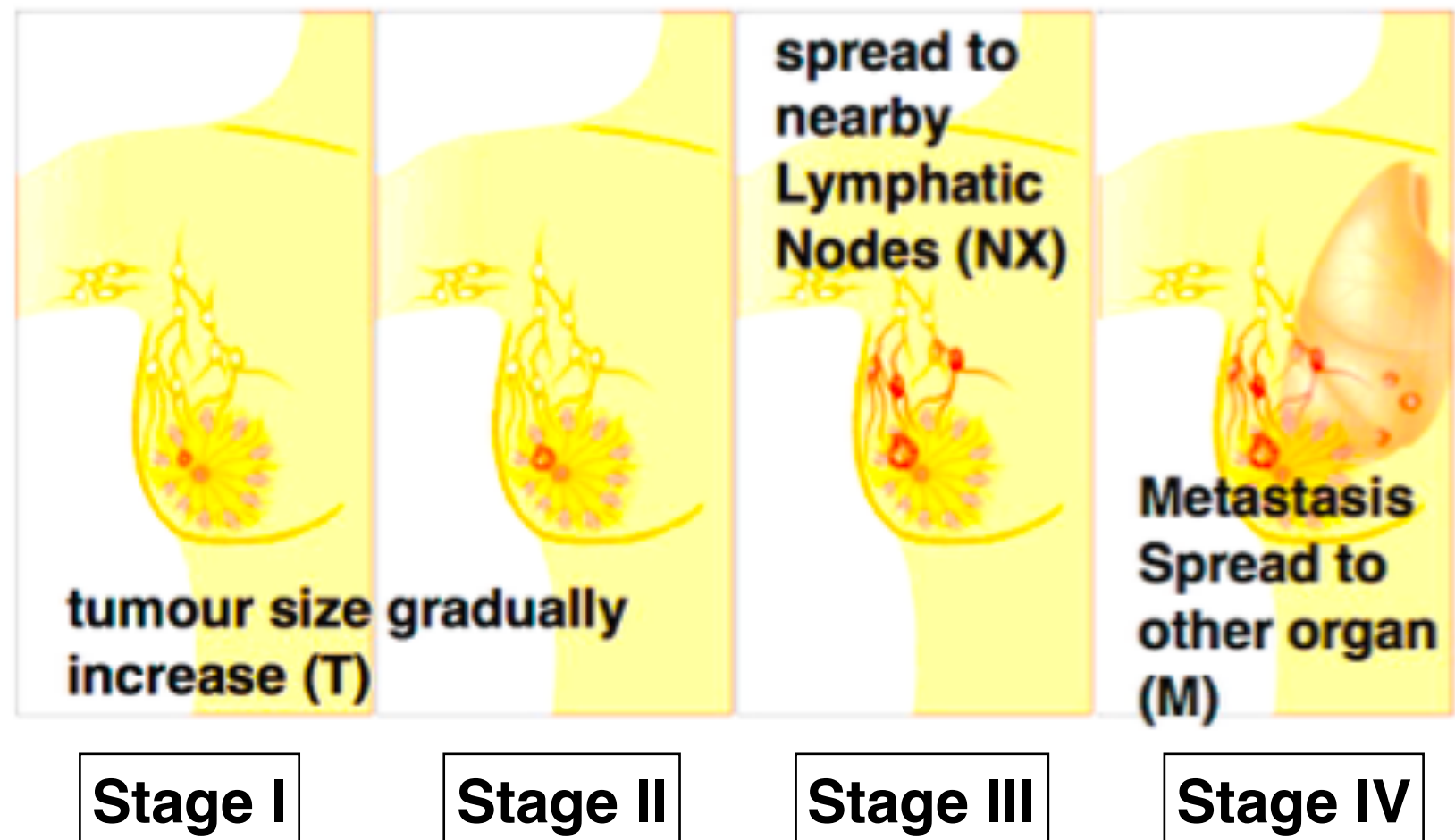
Probabilistic Timed Cancer Automata (ProTCA)

Timed Game Cancer Automata (TGCA)

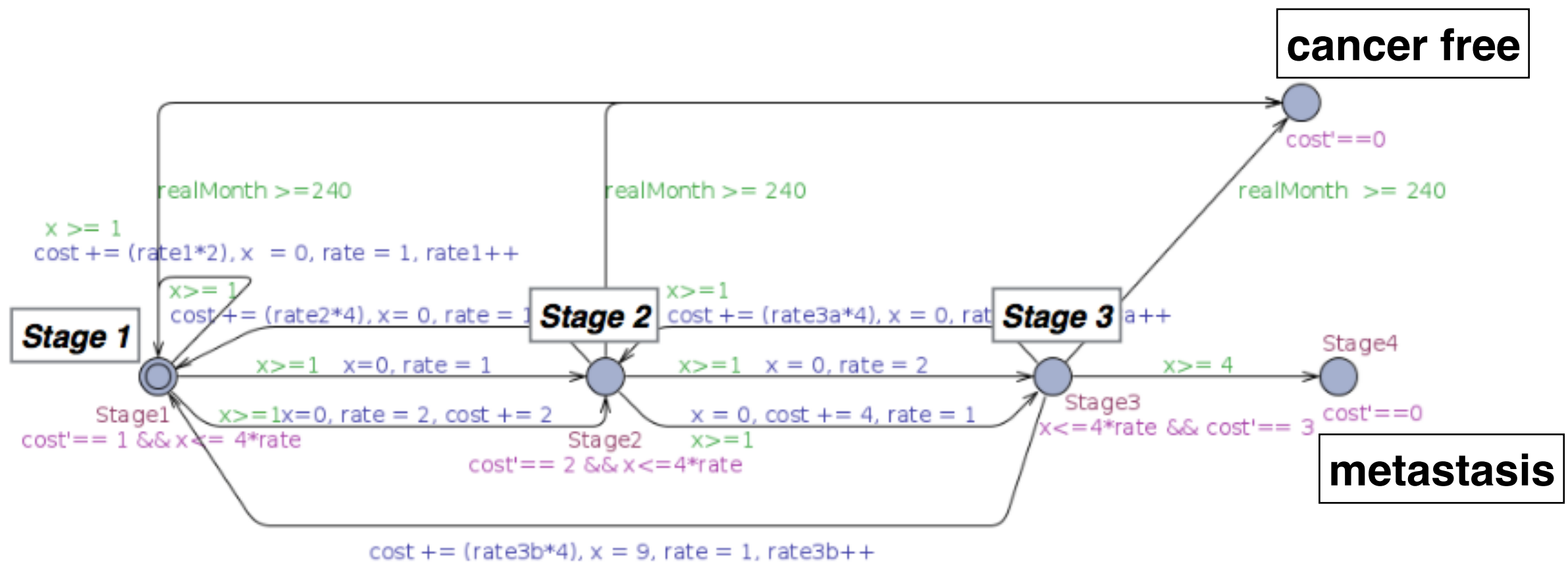
Probabilistic Timed Game Cancer Automata (PTGCA)

TMN Staging

- Tumour size
- Affected Lymphatic Nodes
- Metastasis



Priced Timed Cancer Automata (PTCA)

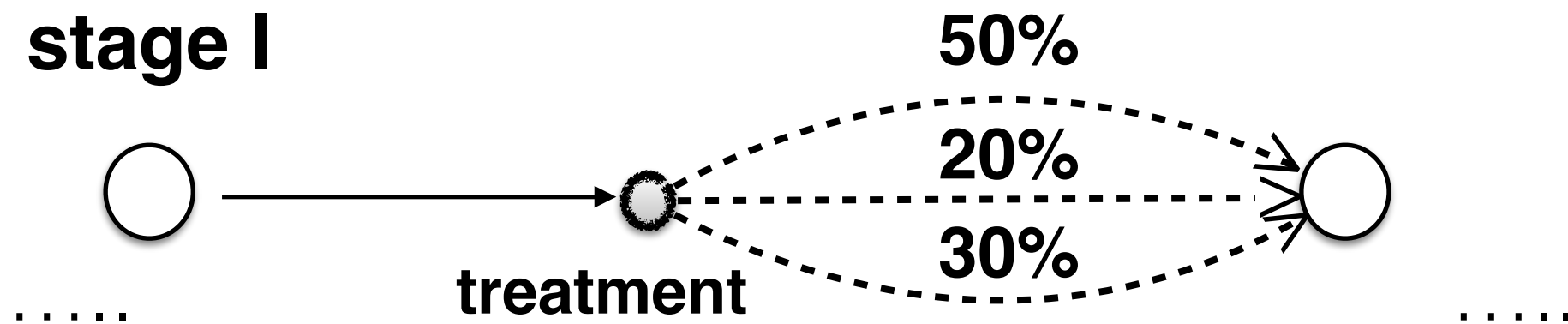


Property specifications

$E \Diamond \text{canFree}$:

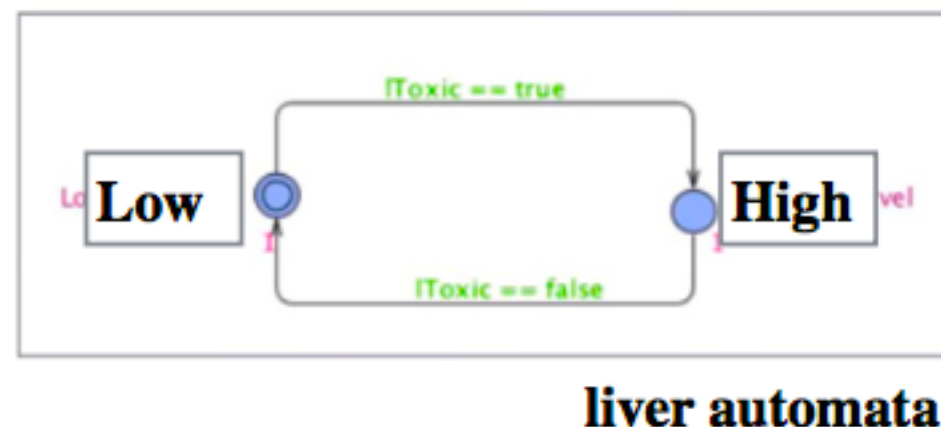
there is exists a path where eventually cancer free condition is reached

Probabilistic Timed Cancer Automata (ProTCA)



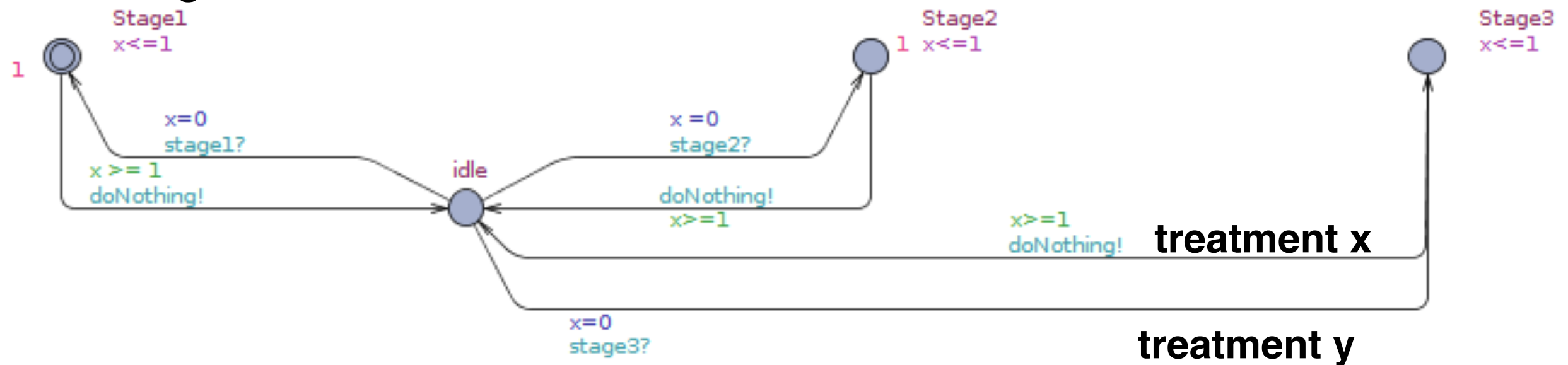
Measuring **Prognosis rate/ Therapy** success rate by using **strategy automata**

Cormobidities

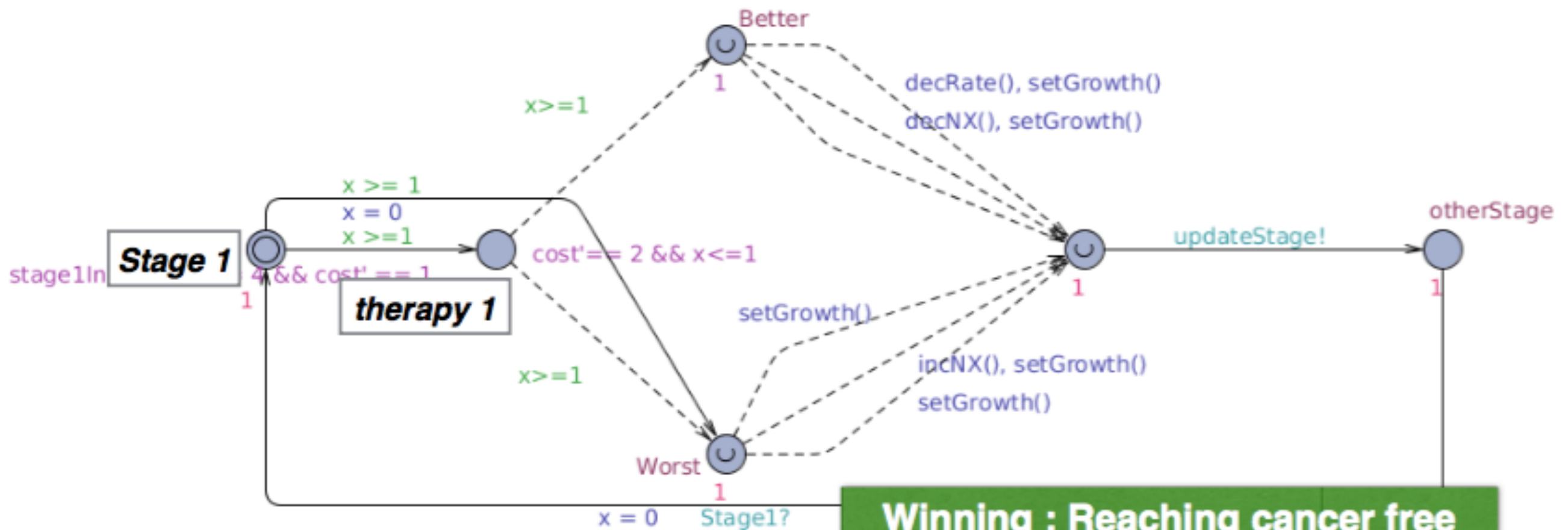


Strategy Automata

cancer stages



Timed Game Cancer Automata (TGCA)

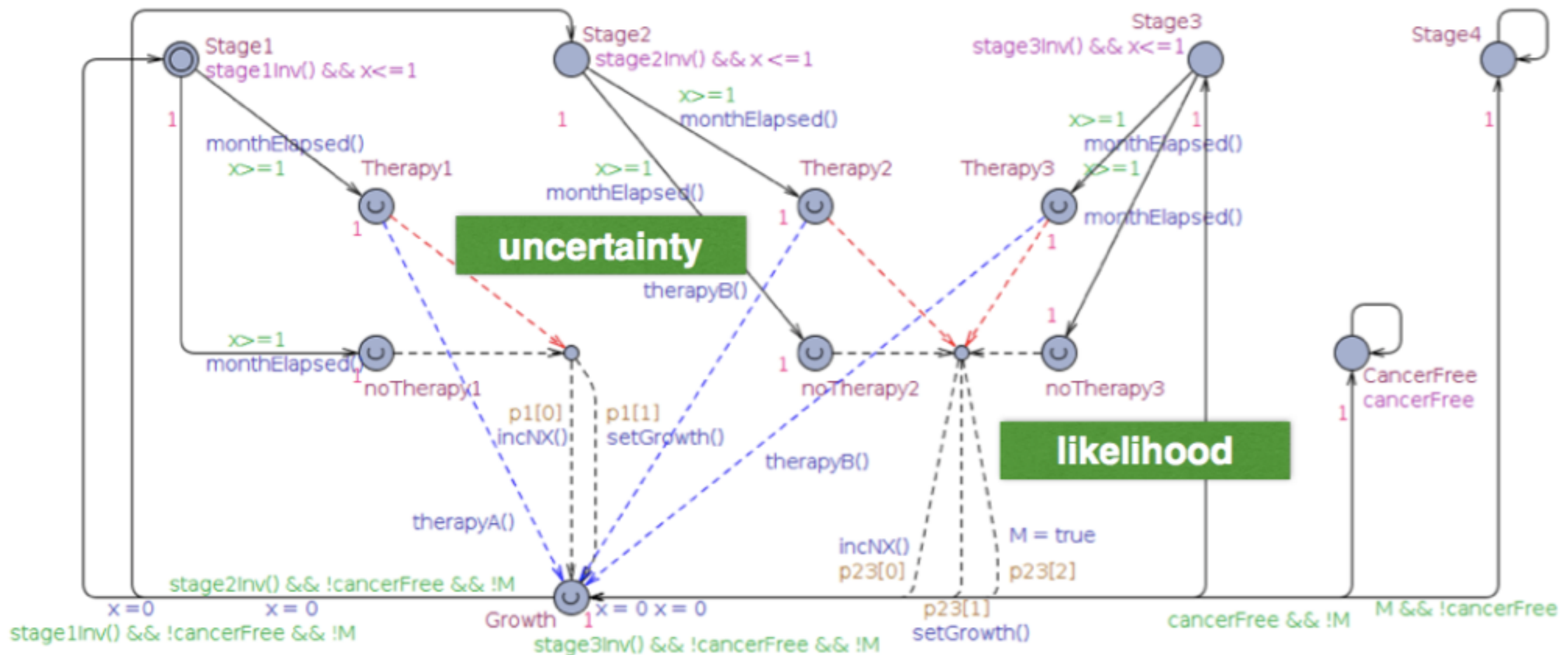


Finding a winning strategy...

control: $A[] \text{!s4.Stage4}$

control: $A[\text{!s4.stage4 U free.CF}]$

Probabilistic Timed Game Cancer Automata



Property Specifications

TCTL:

E[] (!cha.Stage4)

**finding a pathway to avoid
metastasis**

PTCL:

Pr[xRealMonth <= 300] ([] !cha.Stage4)

**the probability to avoid
metastasis**

the cost estimation

E[<=600; 500] (max: cha.cost)

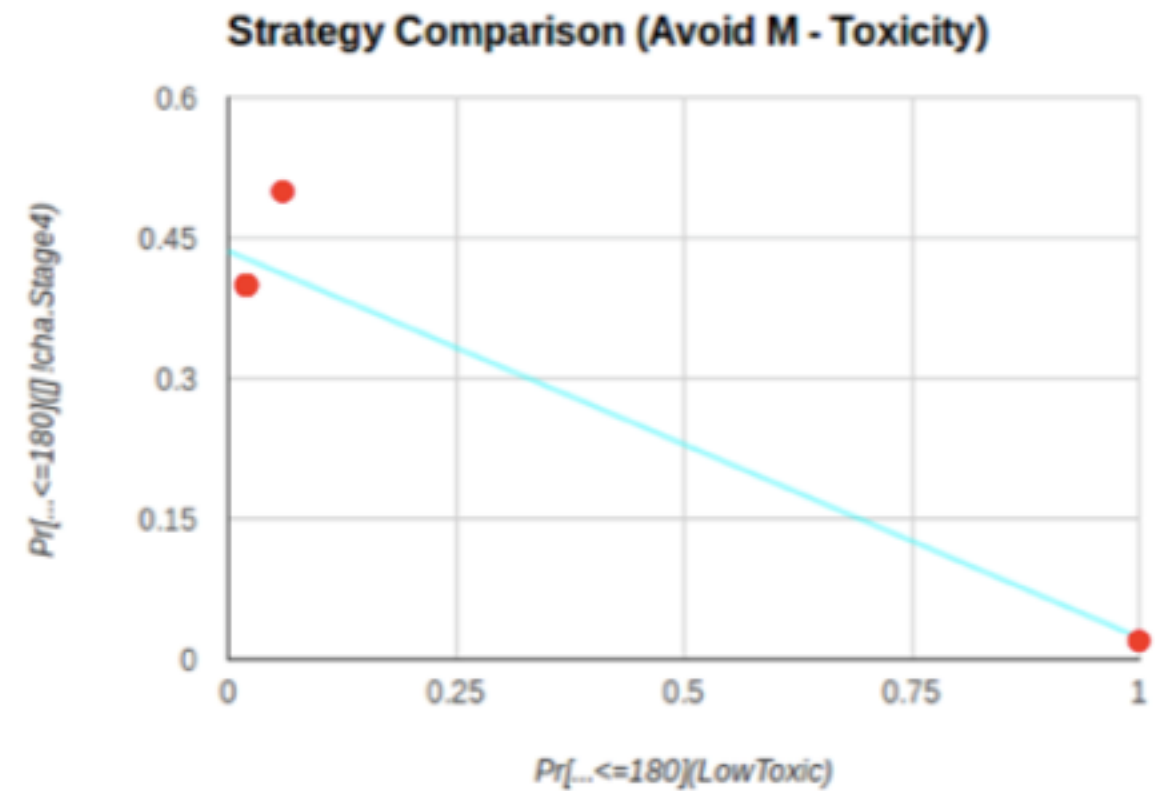
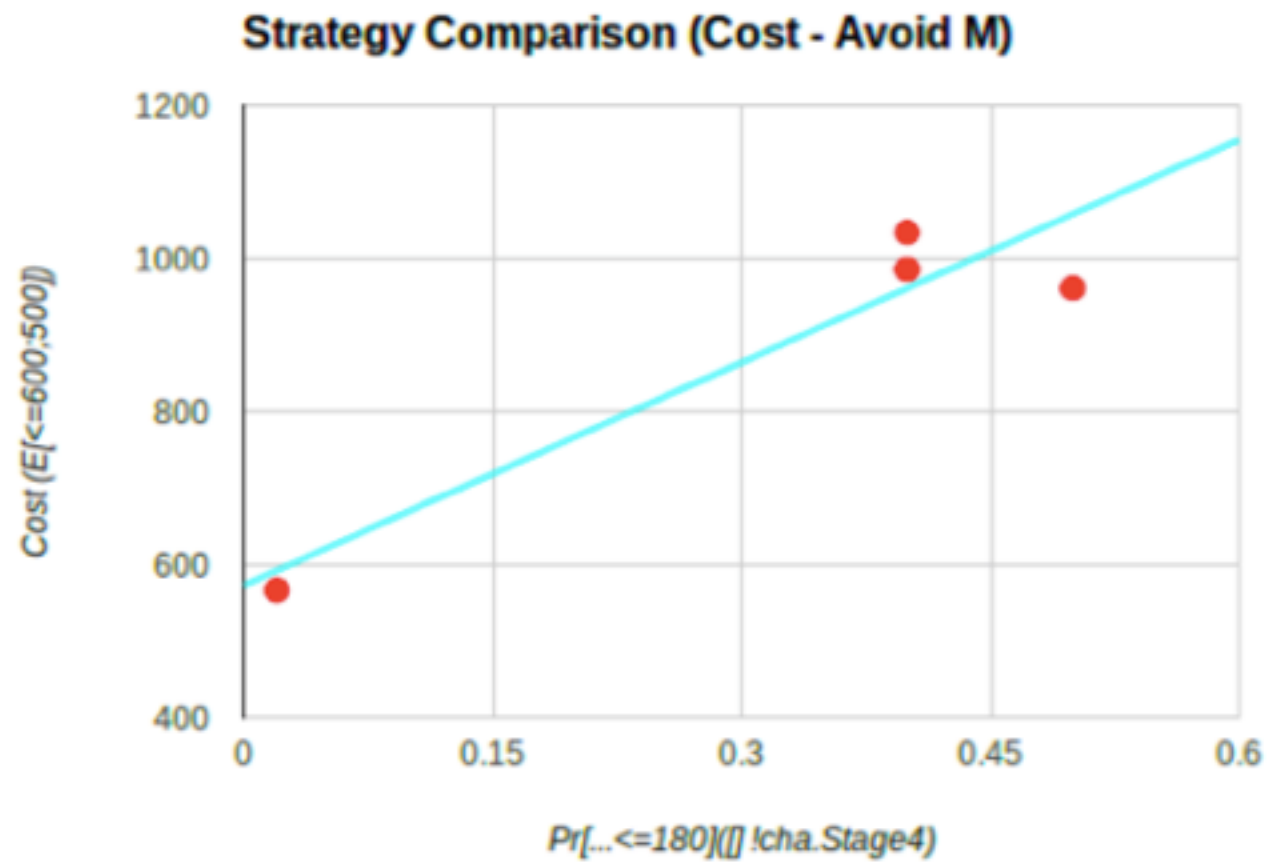
**the probability of having
low liver toxicity**

Pr[xRealMonth in <= 180] ([] liver.LowToxicLevel)

simulate 1 [xrm<=300] logD, M*1000, NX*500

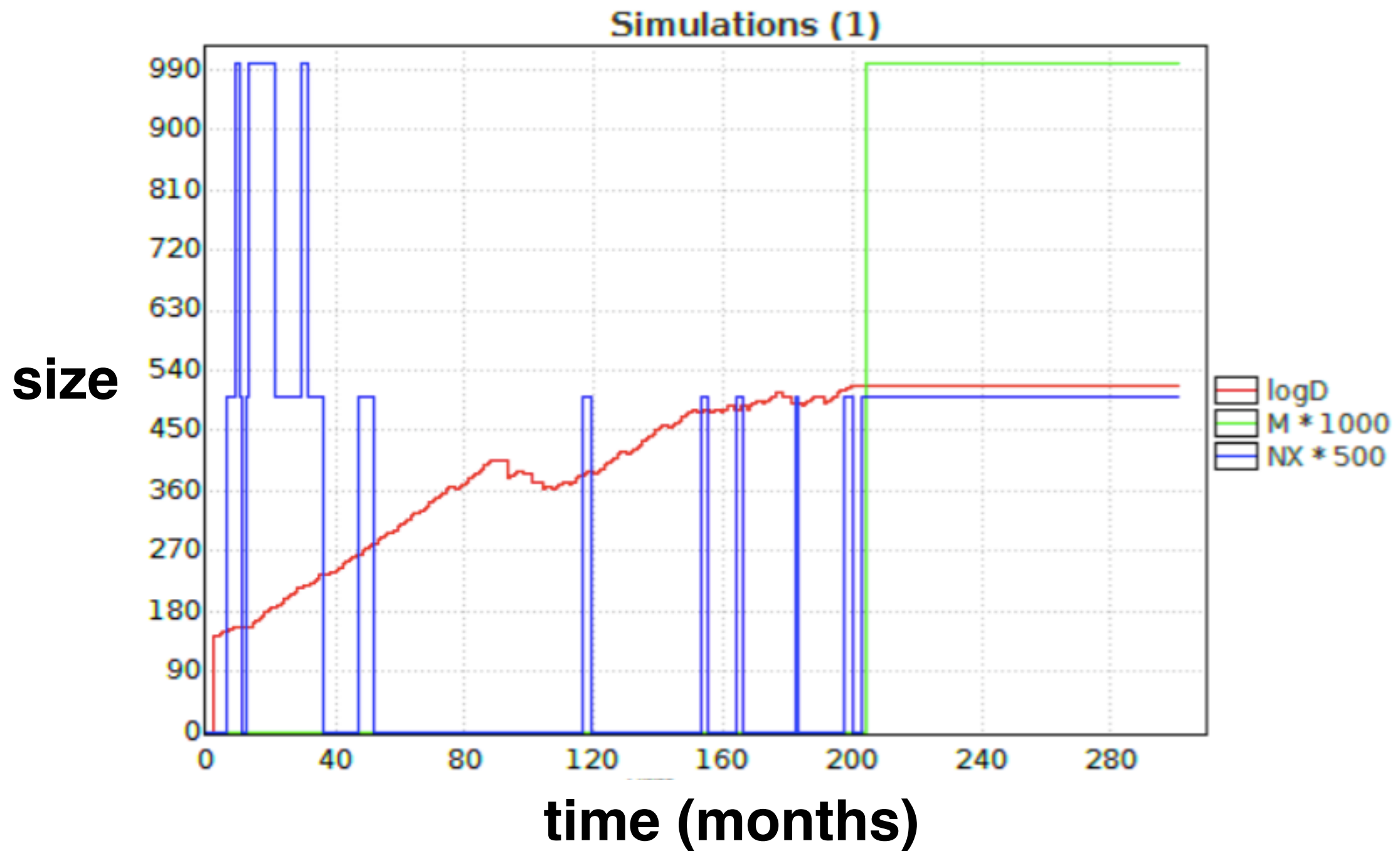
**simulate the growth of
cancer**

Result



The PPTCA strategy comparison

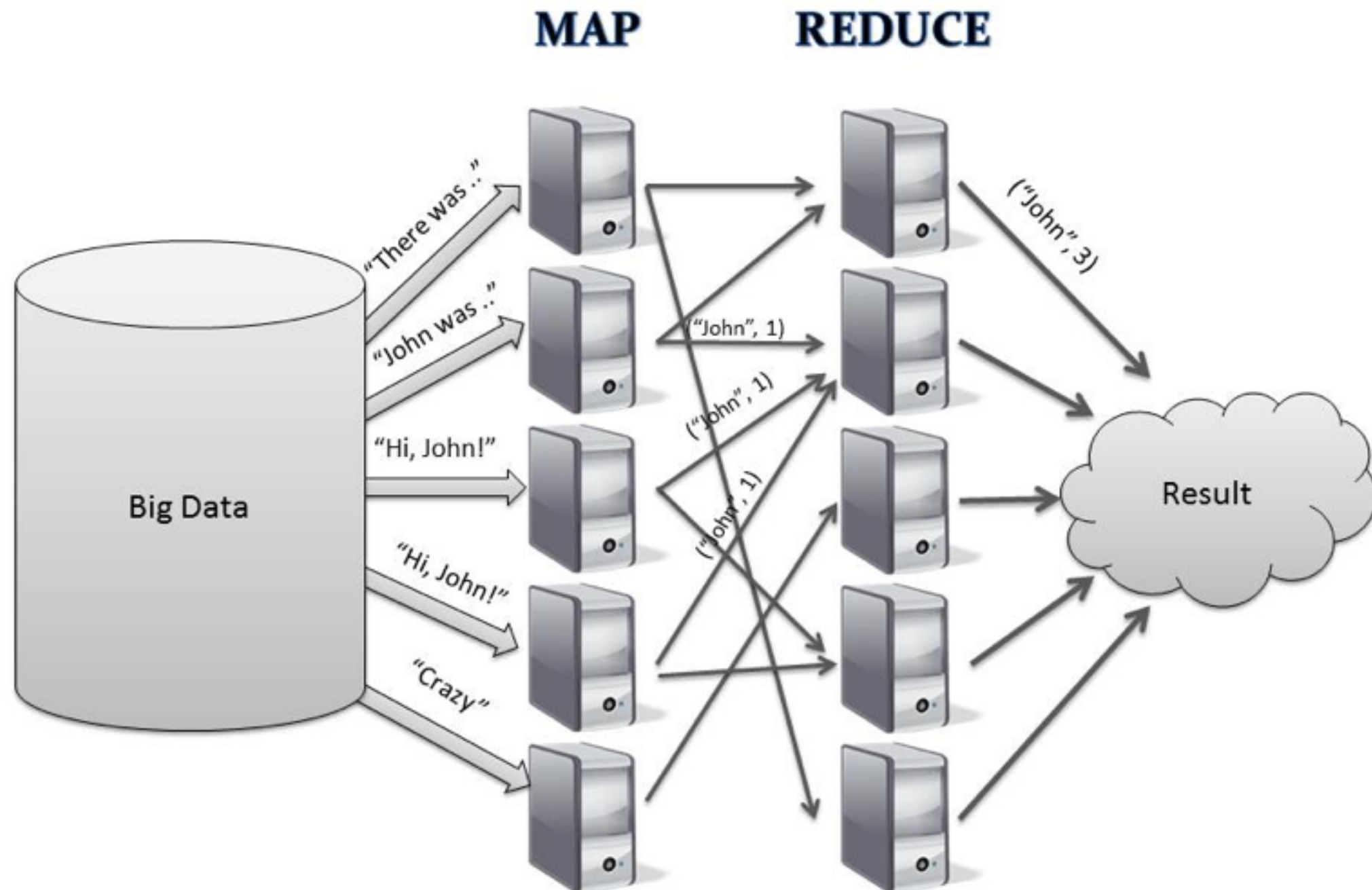
Result



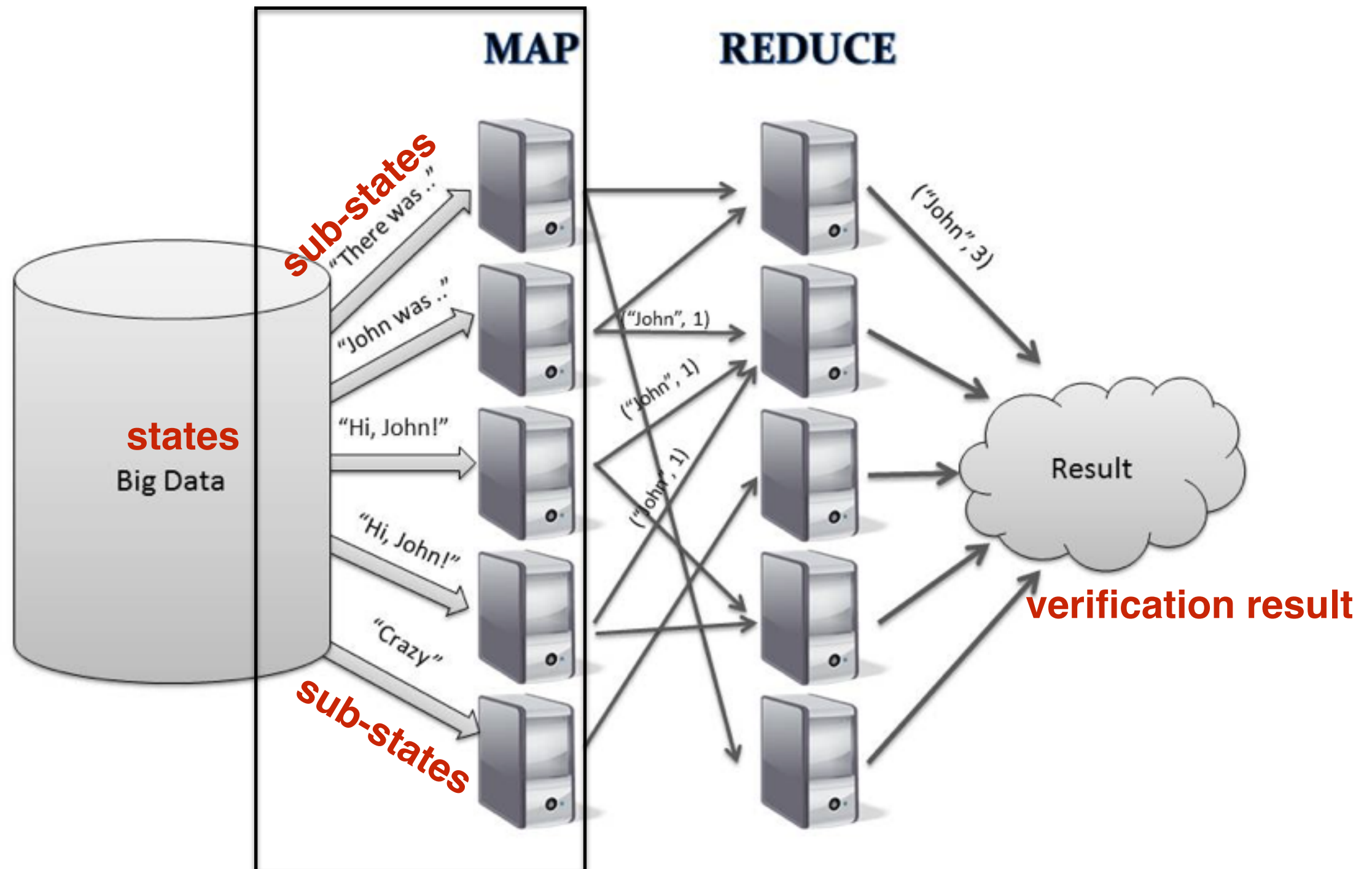
Conclusion & Future works

- **(improve) Data Collections**
- **(include) experts participation**

- **(avoid) State Space Explosion**



- **(avoid) State Space Explosion**



Conclusion & Future works

- **Cancer Automata as the generic model**

THANK YOU