Week 4 Review: Decision Trees

- This review session is completely optional.
  - If the decision-tree concepts introduced in Session 1 are clear to you
  - Then you can skip this review and move on to the practice problems.
  - After that, go ahead and tackle Week 4's homework.

- However if, before trying the practice problems…
  - You'd like an additional look at how to set up and analyze a decision tree
  - Then join me for a review

- Example from patent litigation
  - Cellectis and Precision BioSciences

Background on Cellectis and Precision BioSciences

- Both develop genomic editing technologies that they sell for use in genetic engineering.

- In 2008 Cellectis sued Precision BioSciences for patent infringement, and the litigation ended in 2013.

- Imagine that it is 2008….Cellectis's legal advisors note that the litigation process has three well-established stages.

  1. First, the court will decide whether or not Cellectis's patent is valid.
  2. If the patent is considered valid, then the court will determine whether or not Precision BioSciences has infringed on Cellectis's patent.
  3. If there is a determination of infringement, the court will then determine the magnitude of the damages payable to Cellectis

  If the court rules against Cellectis in the 1st or 2nd phase, then litigation ends.

Cellectis estimates the probabilities and cash flows

- Cellectis and its attorneys estimate the probabilities of Cellectis's litigation advancing from one stage to the next
  1. The chances of the patent being found valid in stage 1 are 2/3.
  2. Given a valid patent, the chances that Precision BioSciences will be found to have infringed in phase 2 are only 1/4.

- They estimate possible damage awards in Phase 3 by multiplying various royalty percentages by the value of the Precision BioSciences' contracts
  - Four equally likely outcomes: $20 million, $30 million, $40 million, $50 million.

- The legal team estimates its fees for each of the three trial stages
  - $3 million for the first stage, patent validity
  - $5 million for the second stage, determination of infringement
  - $1 million for the third stage, damages

Cellectis's decision problem

- When moving from one stage of litigation to the next…
  - If Cellectis loses at that stage, it must stop and pay its attorneys' fees up through that stage.
  - Even if Cellectis wins at that stage, it can decide to stop litigation and pay only its attorneys' fees up through that stage.

- More generally, Cellectis must decide
  - Whether or not to litigate, to sue Precision BioSciences for patent infringement
  - If it litigates, then after each stage it wins, should it continue litigation or stop?

Q1: Construct a decision tree for Cellectis

- Construct a tree with decision nodes (squares), event nodes (circles), and payouts (triangles). Write down the name and cash flows associated with each decision and event.
- For each event node, write down the probabilities that they occur. Make sure that the probabilities add up to one.
- For each payout, use the revenues and costs on the branches that lead up to it to calculate its value.

Q2: Analyze Cellectis's decision tree

- What is Cellectis's maxi-min set of decisions?
- What is Cellectis's maxi-max set of decisions?
- What set of decisions maximizes Cellectis's expected value?

Q1: construct a decision tree for Cellectis

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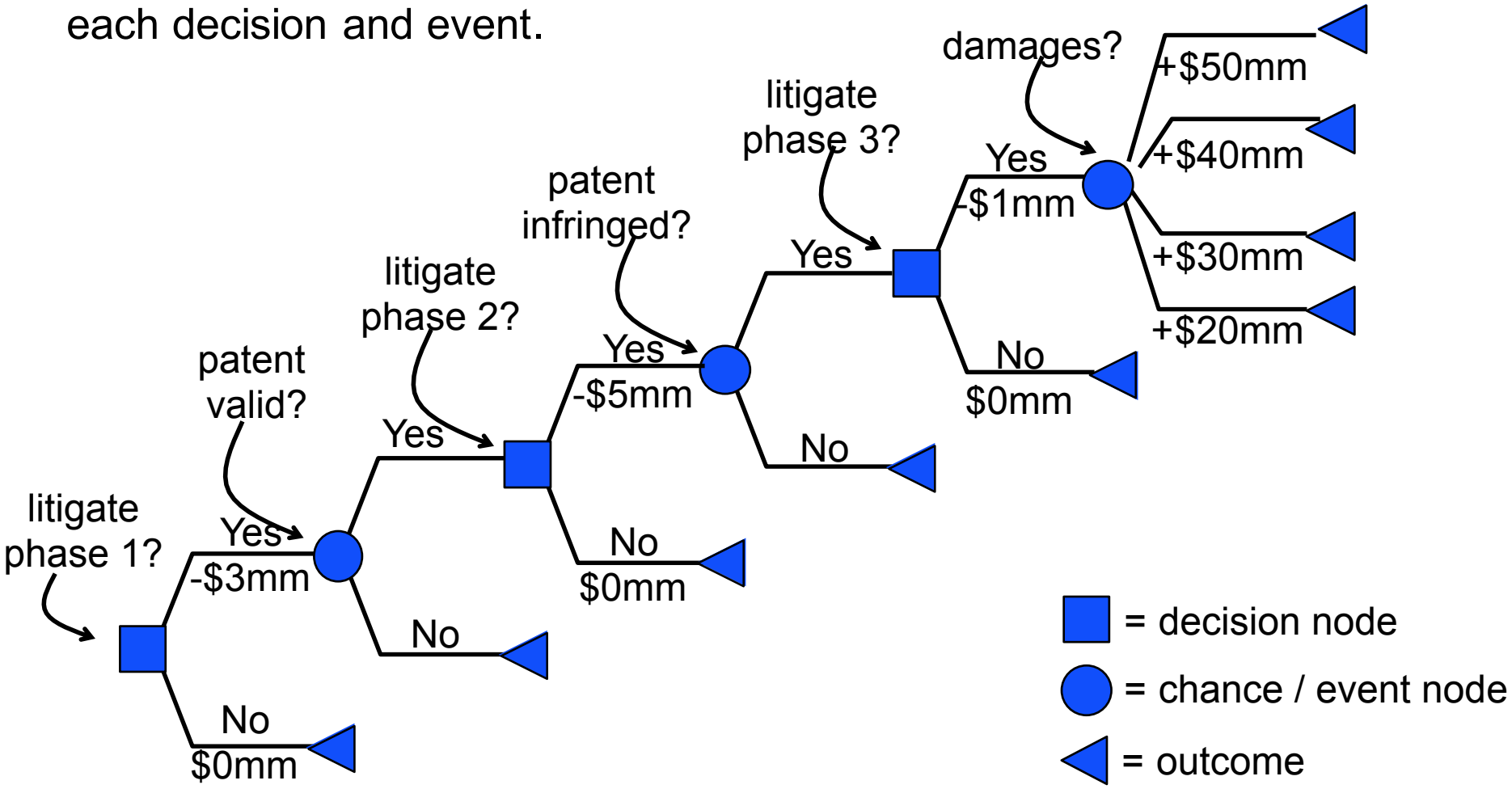

Q1: construct a decision tree for Cellectis

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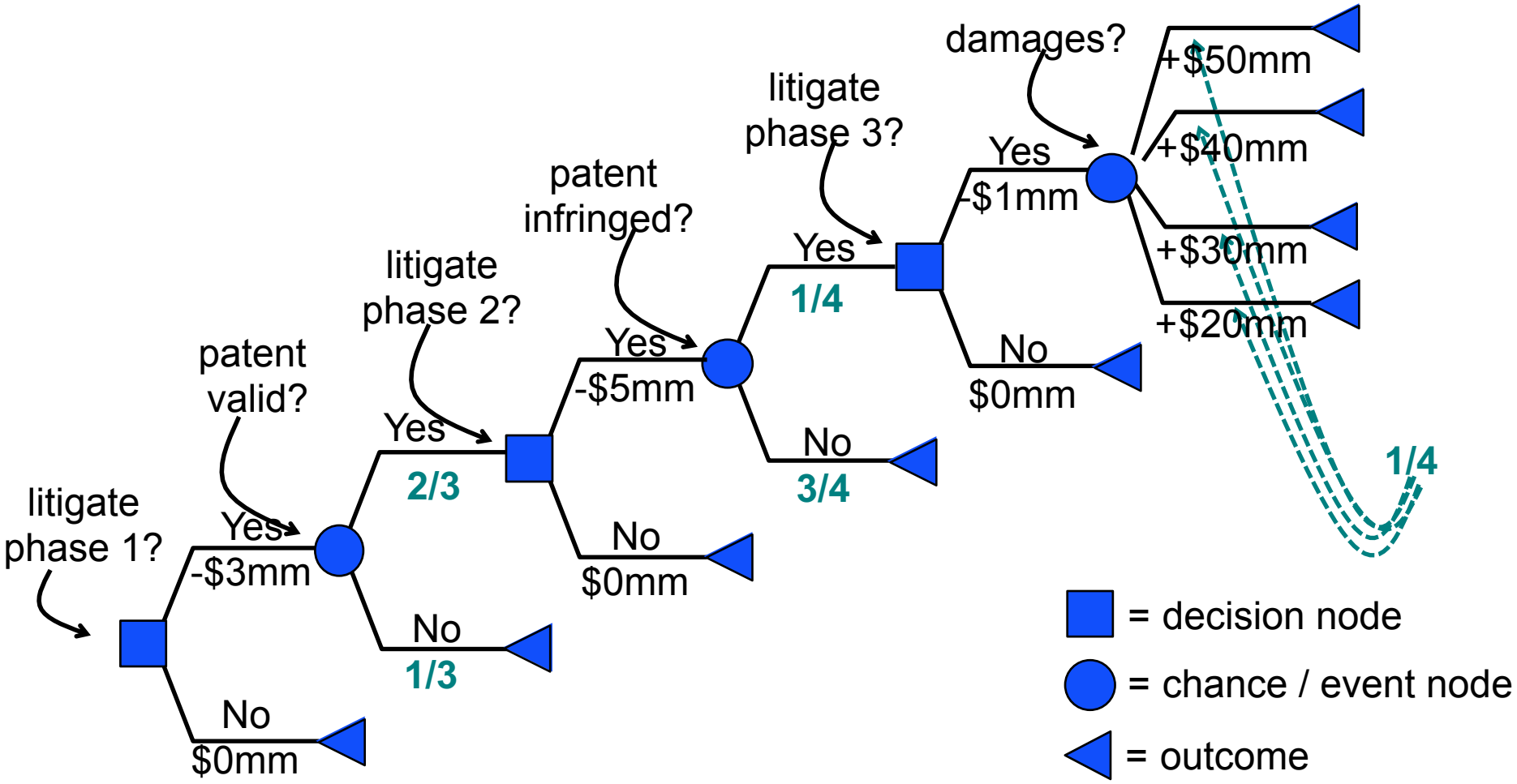

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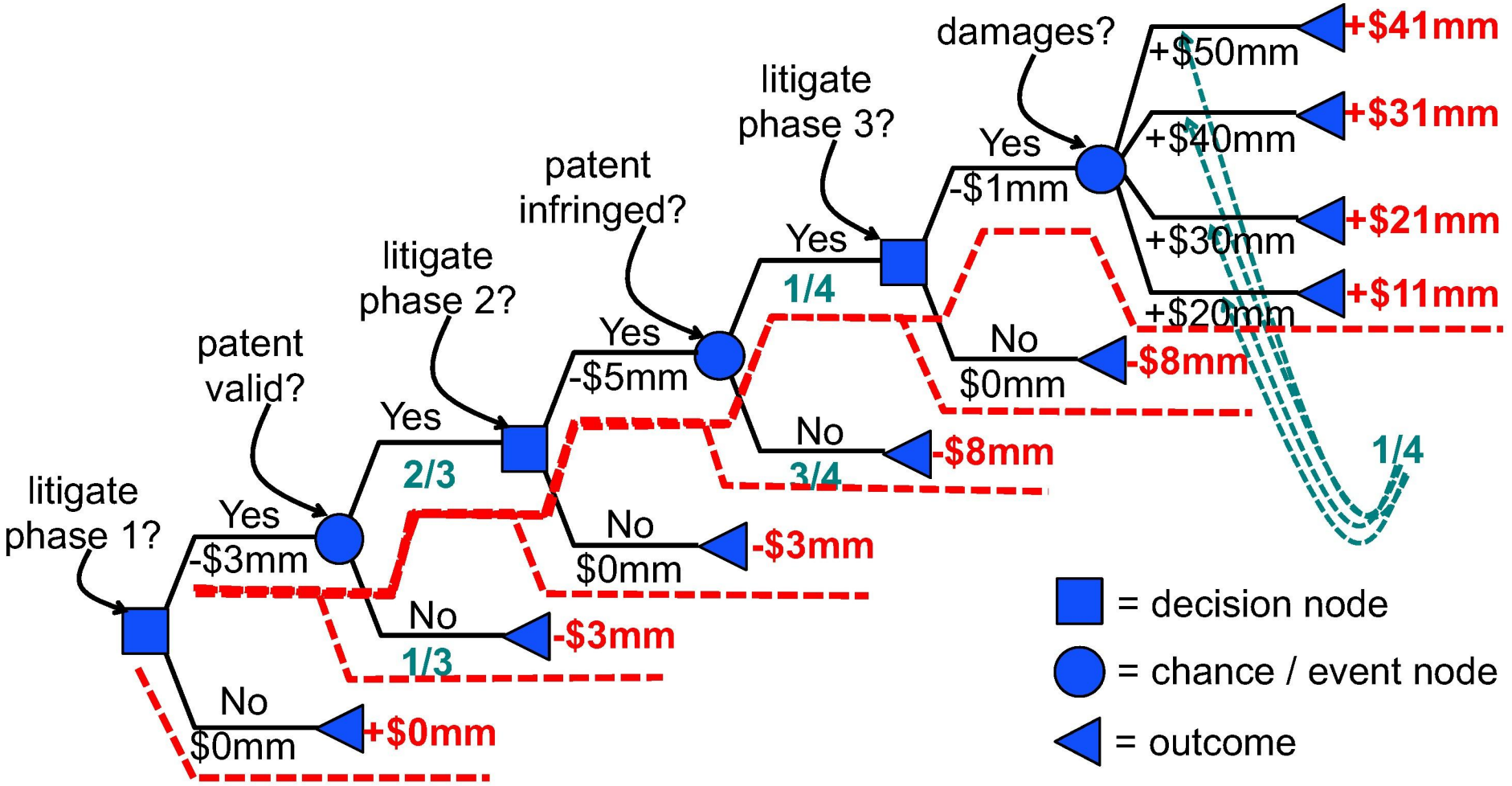
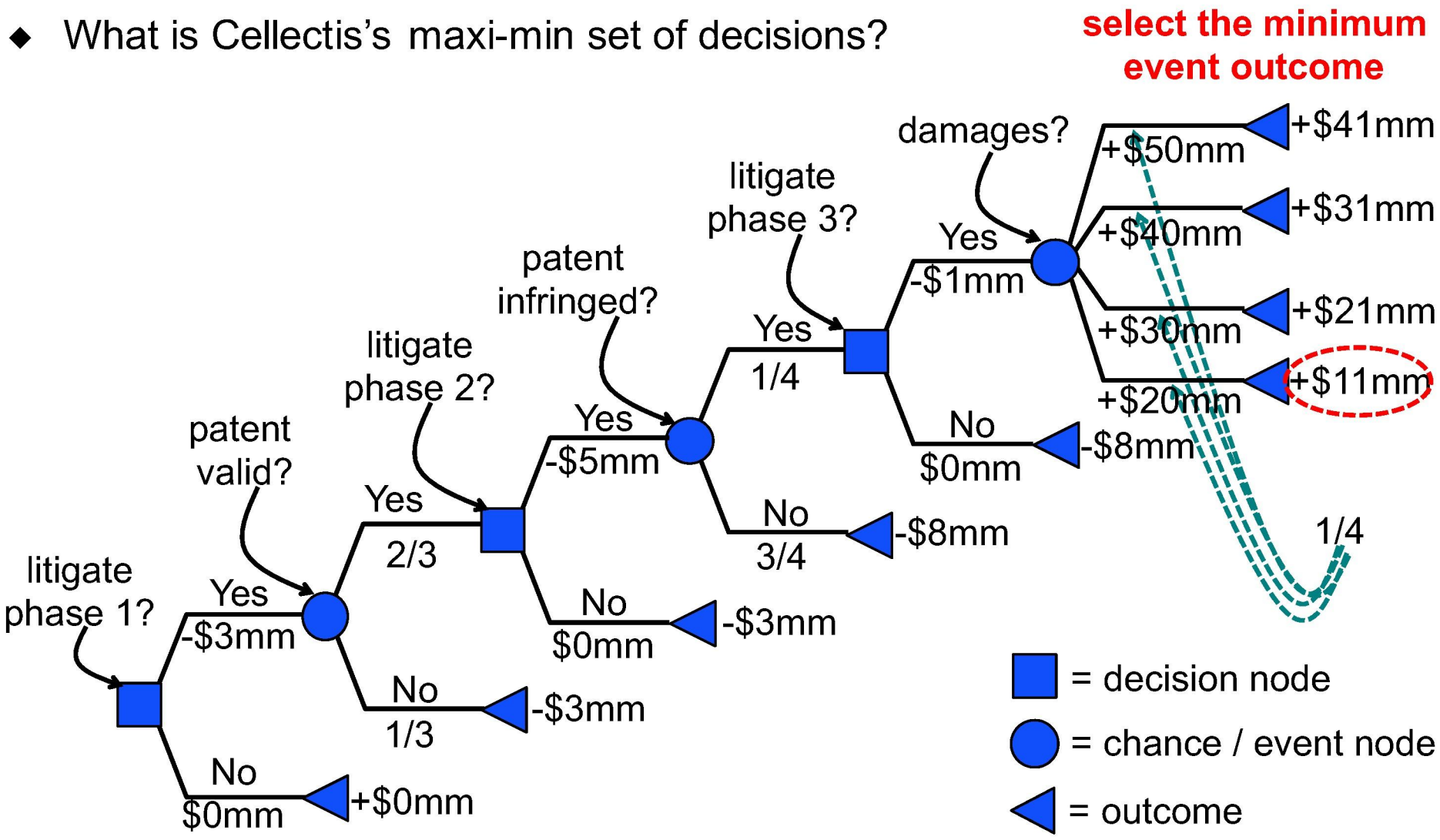


Q2: analyze Cellectis's decision tree

- What is Cellectis's maxi-min set of decisions?
  - Remember that maxi-min decisions maximize the minimum outcome
  - To identify them, we start at the tree's outcomes and work backward to its root
  - At each event node, we choose the minimum outcome
  - At each decision node, we choose the outcome-maximizing decision

Q2: analyze Cellectis's decision tree

- What is Cellectis's maxi-min set of decisions?



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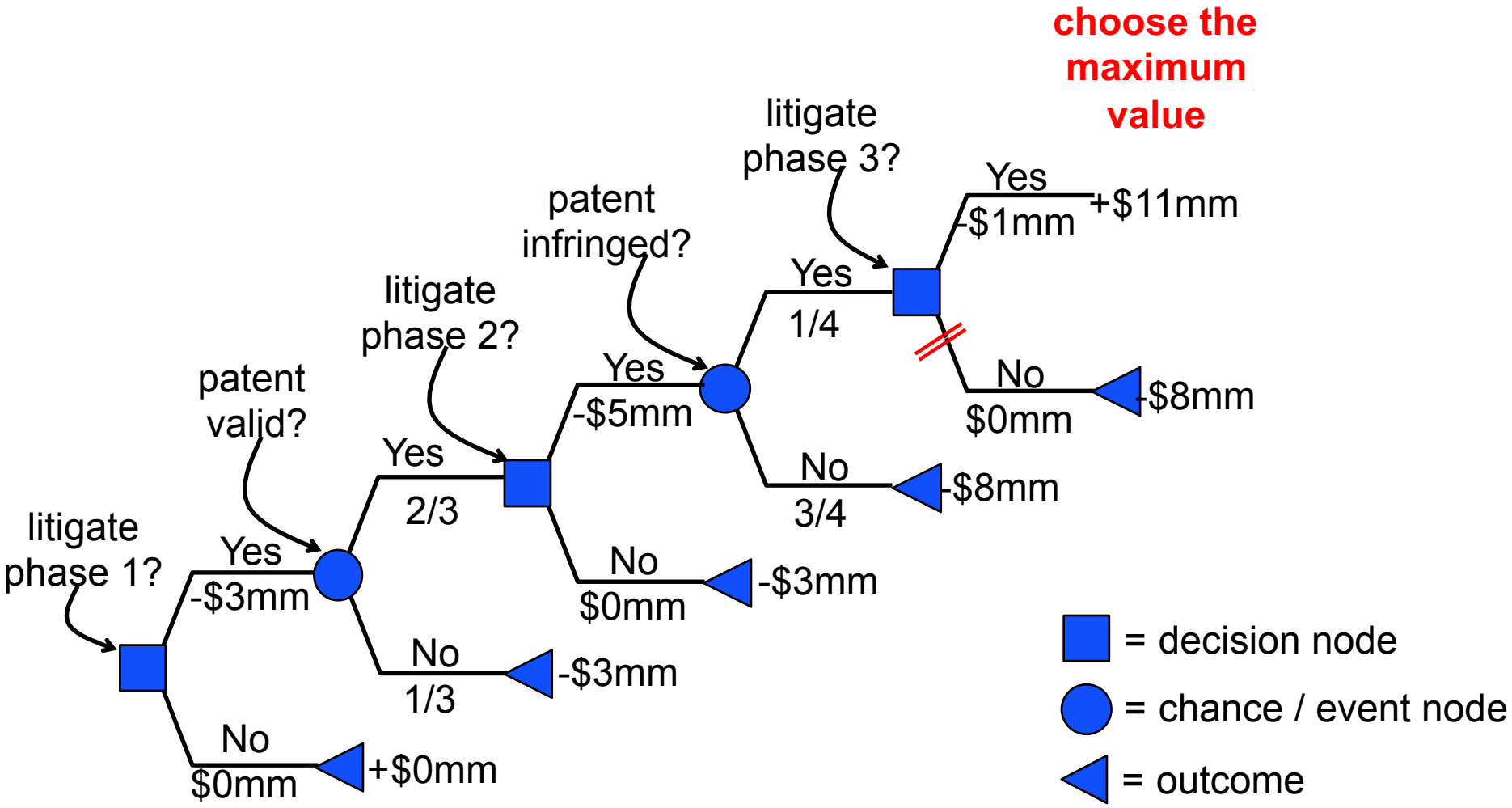

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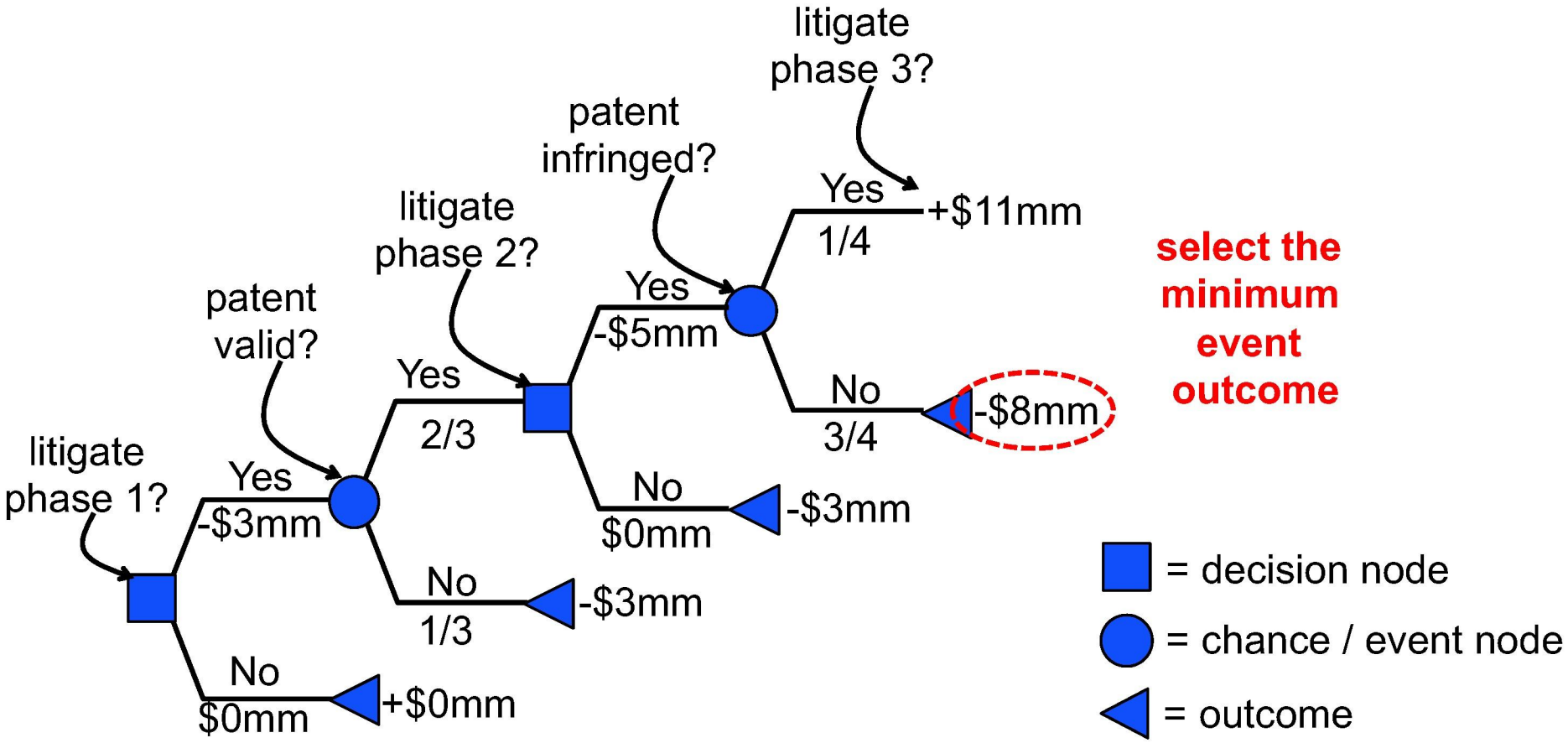

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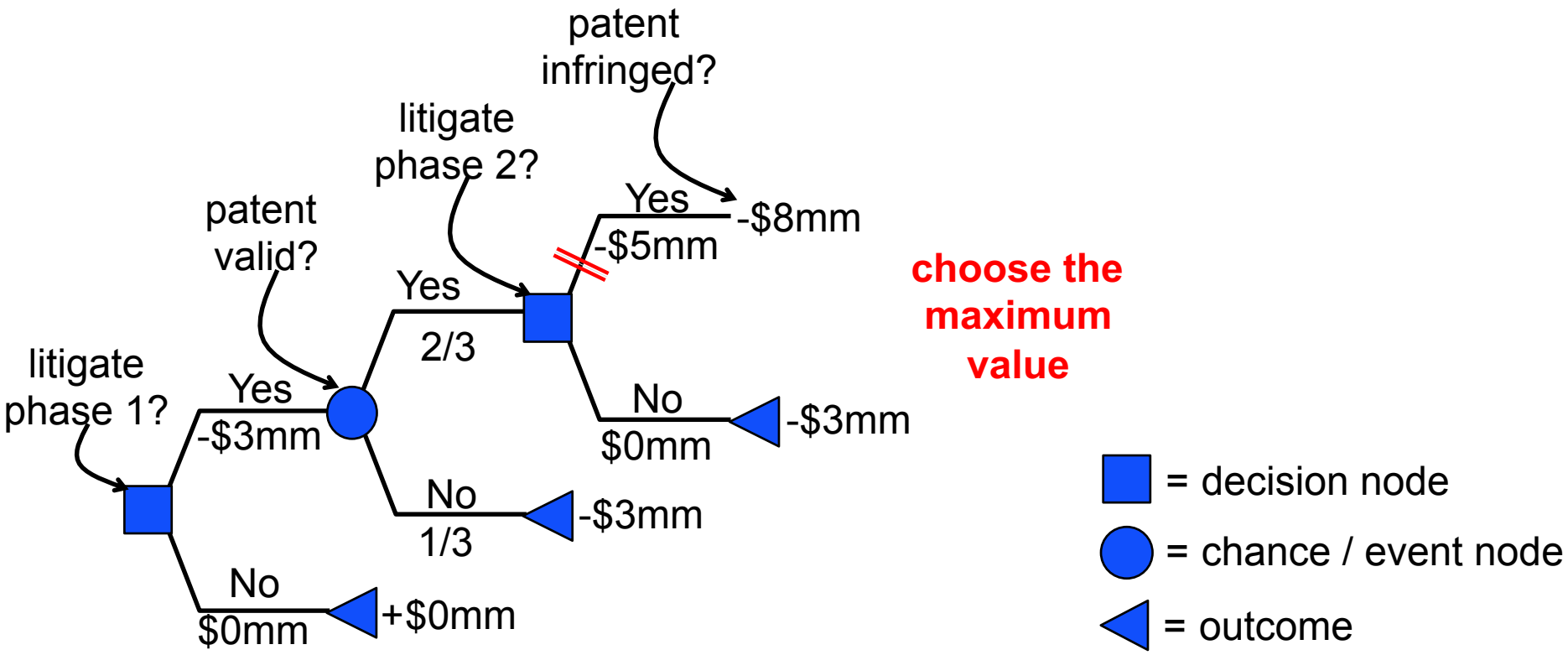

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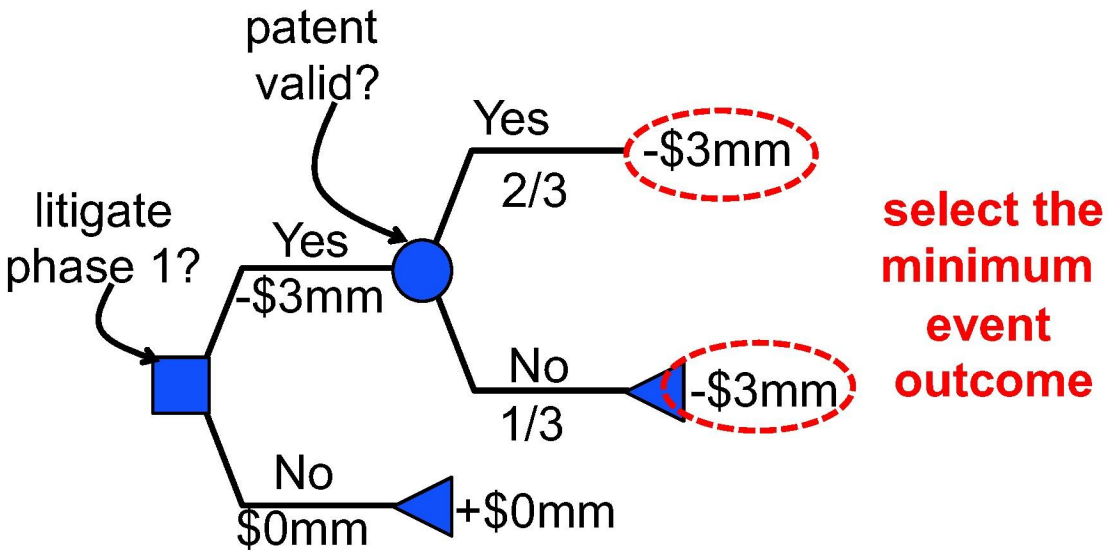


select the minimum event outcome

= decision node

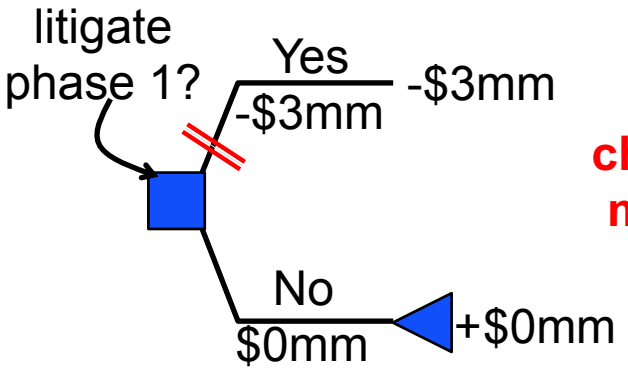
= chance / event node

= outcome

Q2: analyze Cellectis's decision tree

- What is Cellectis's maxi-min set of decisions?

To maximize its minimum payout,
Cellectis should not enter into litigation at all.



choose the maximum value

= decision node
= chance / event node
= outcome

Q2: analyze Cellectis's decision tree

- What is Cellectis's maxi-max set of decisions?
  - Remember that maxi-max decisions maximize the maximum outcome
  - To identify them, we start at the tree's outcomes and work backward to its root
  - At each event node, we choose the maximum outcome
  - At each decision node, we choose the outcome-maximizing decision

Q2: analyze Cellectis's decision tree

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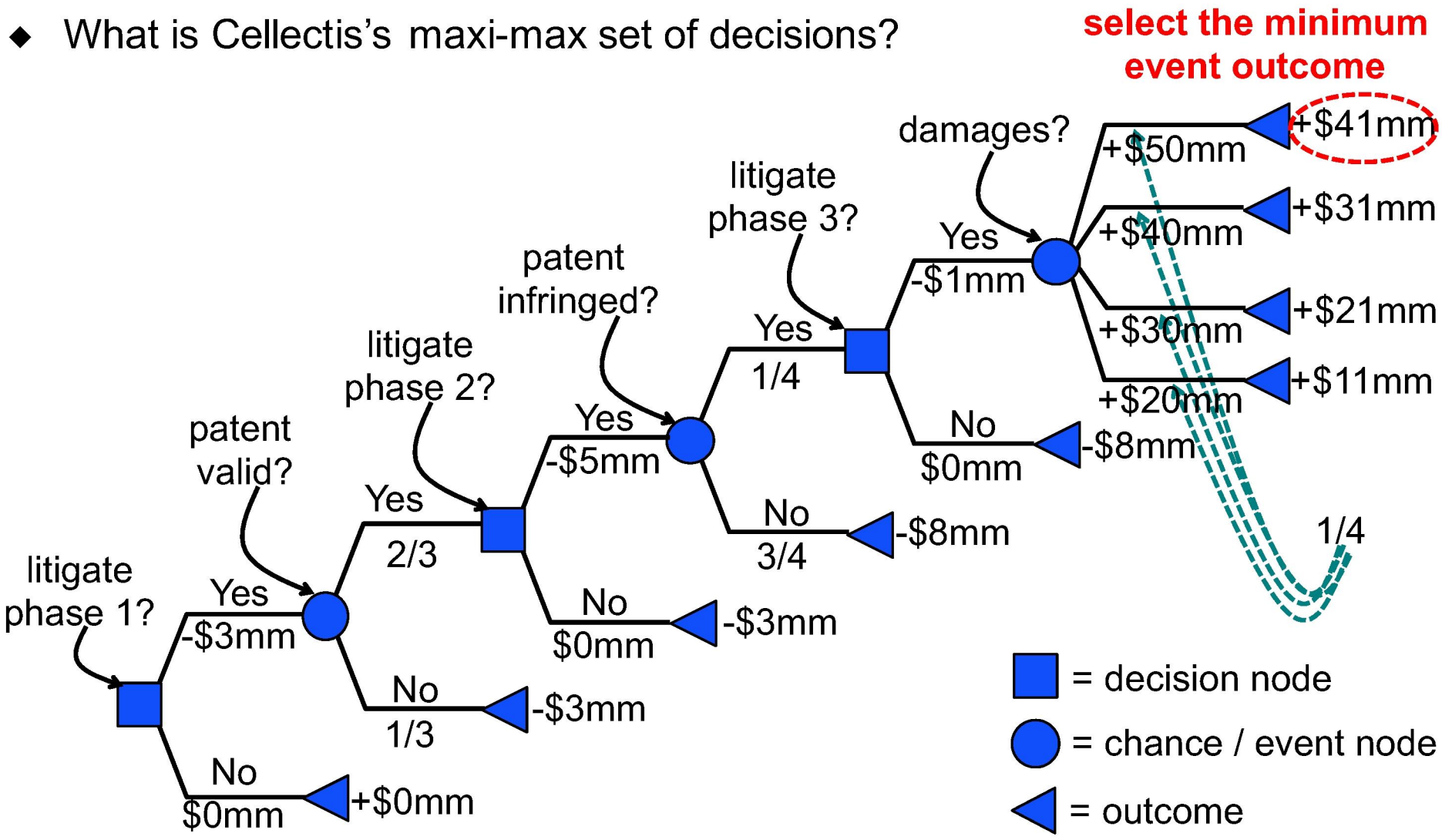

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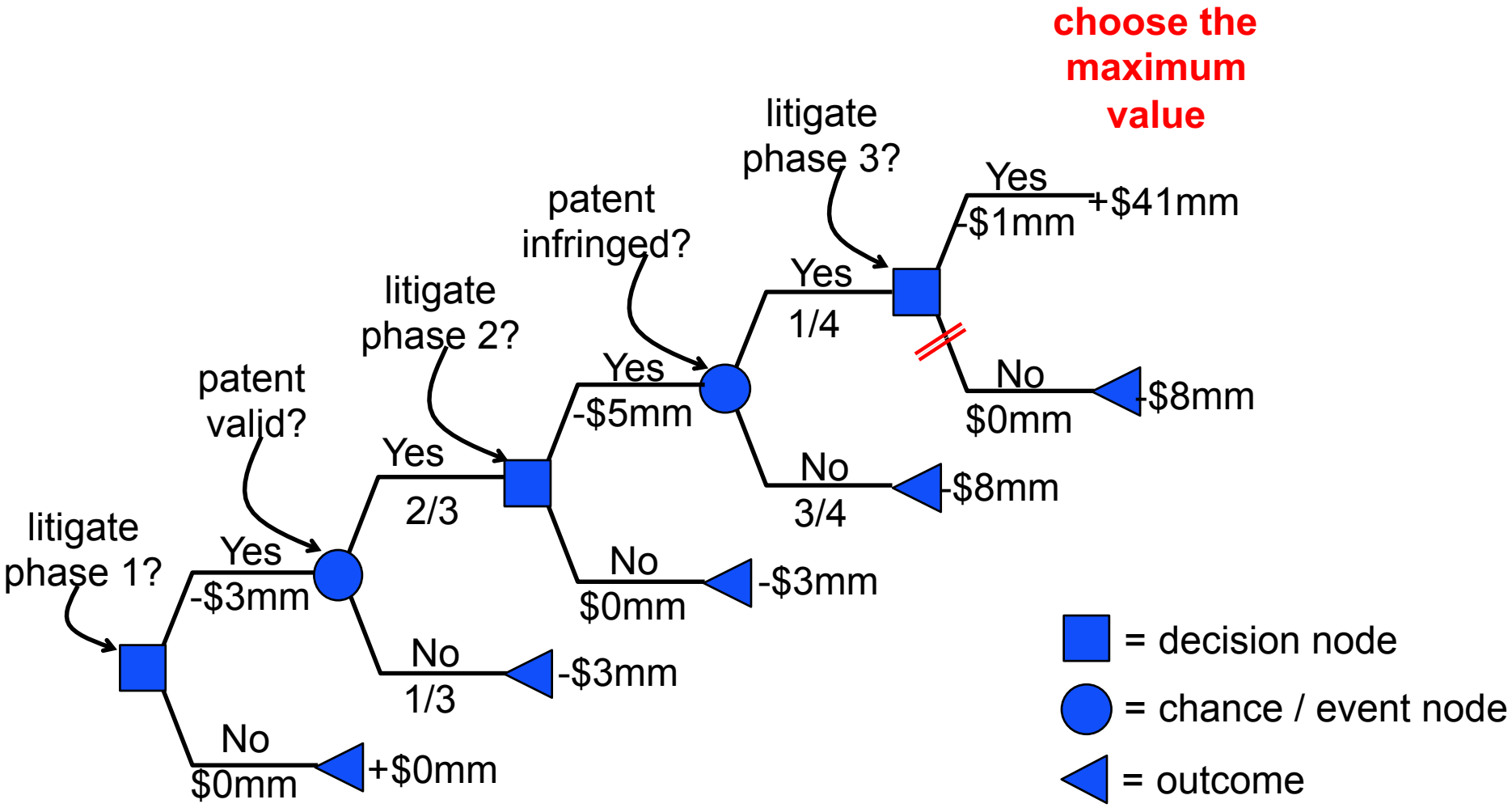

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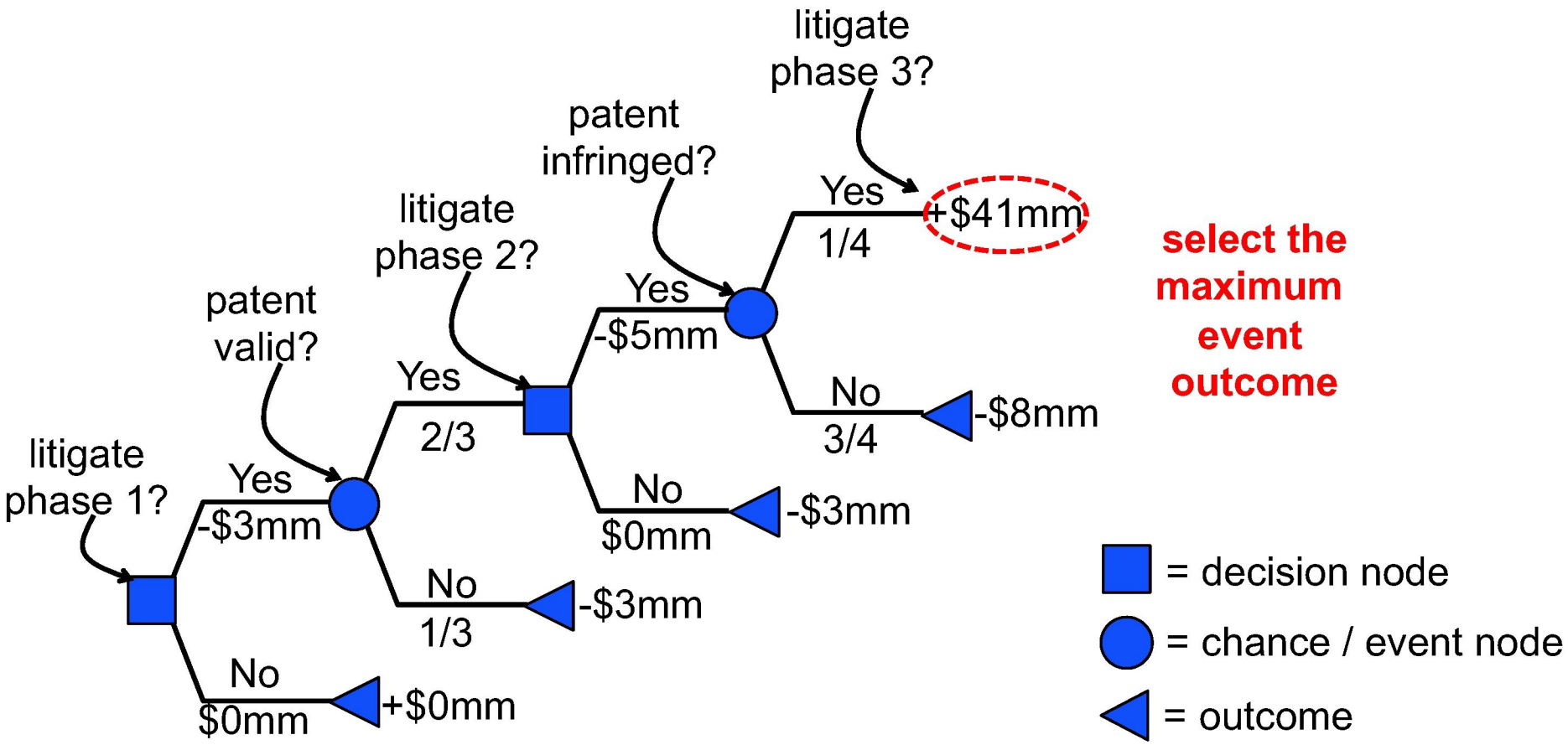

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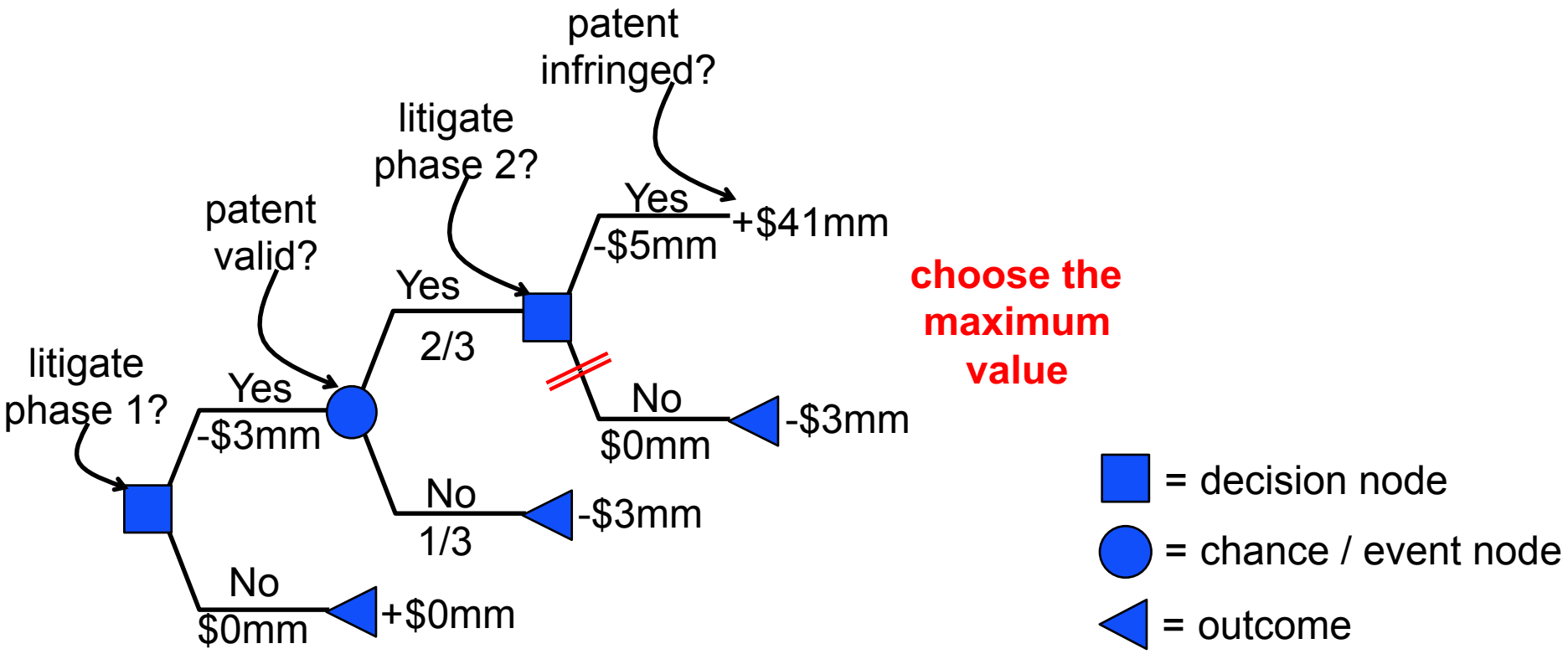

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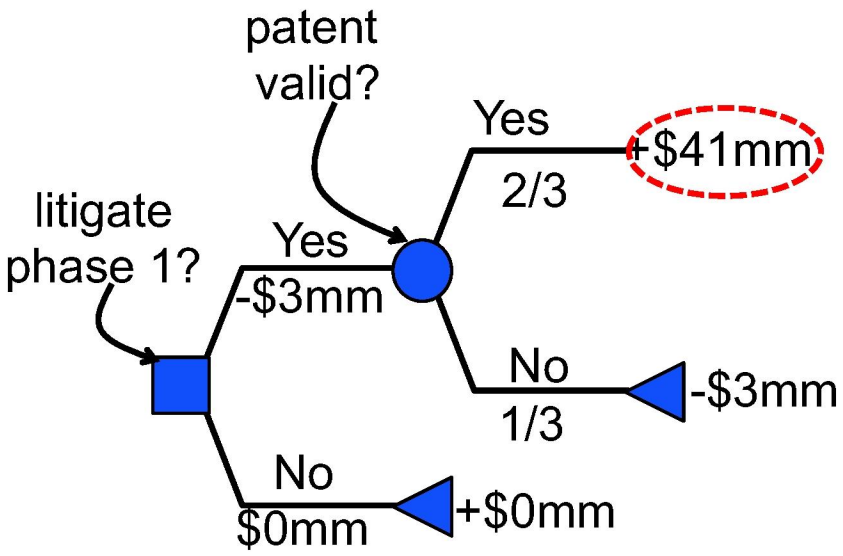

select the maximum event outcome

= decision node

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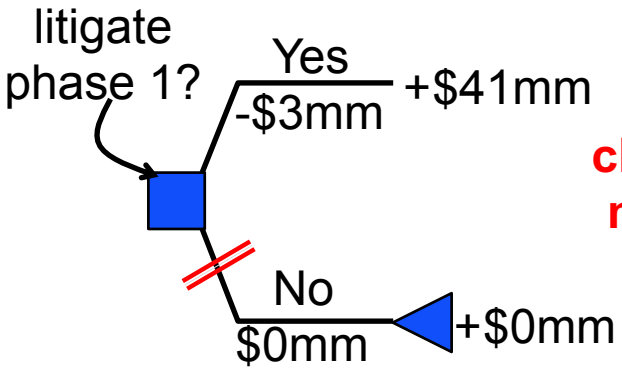
Q2: analyze Cellectis's decision tree

- What is Cellectis's maxi-max set of decisions?

To maximize its maximum payout, Cellectis should proceed through all stages of litigation.



choose the maximum value

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= outcome

Q2: analyze Cellectis's decision tree

- What set of decisions maximizes Cellectis's expected value?
  - As before, we start at the tree's outcomes and work backward to its root
  - At each event node, we calculate the expected value of the outcomes
    - » That's the weighted average of the outcomes, with probabilities as weights.
  - At each decision node, we choose the expected-value-maximizing decision

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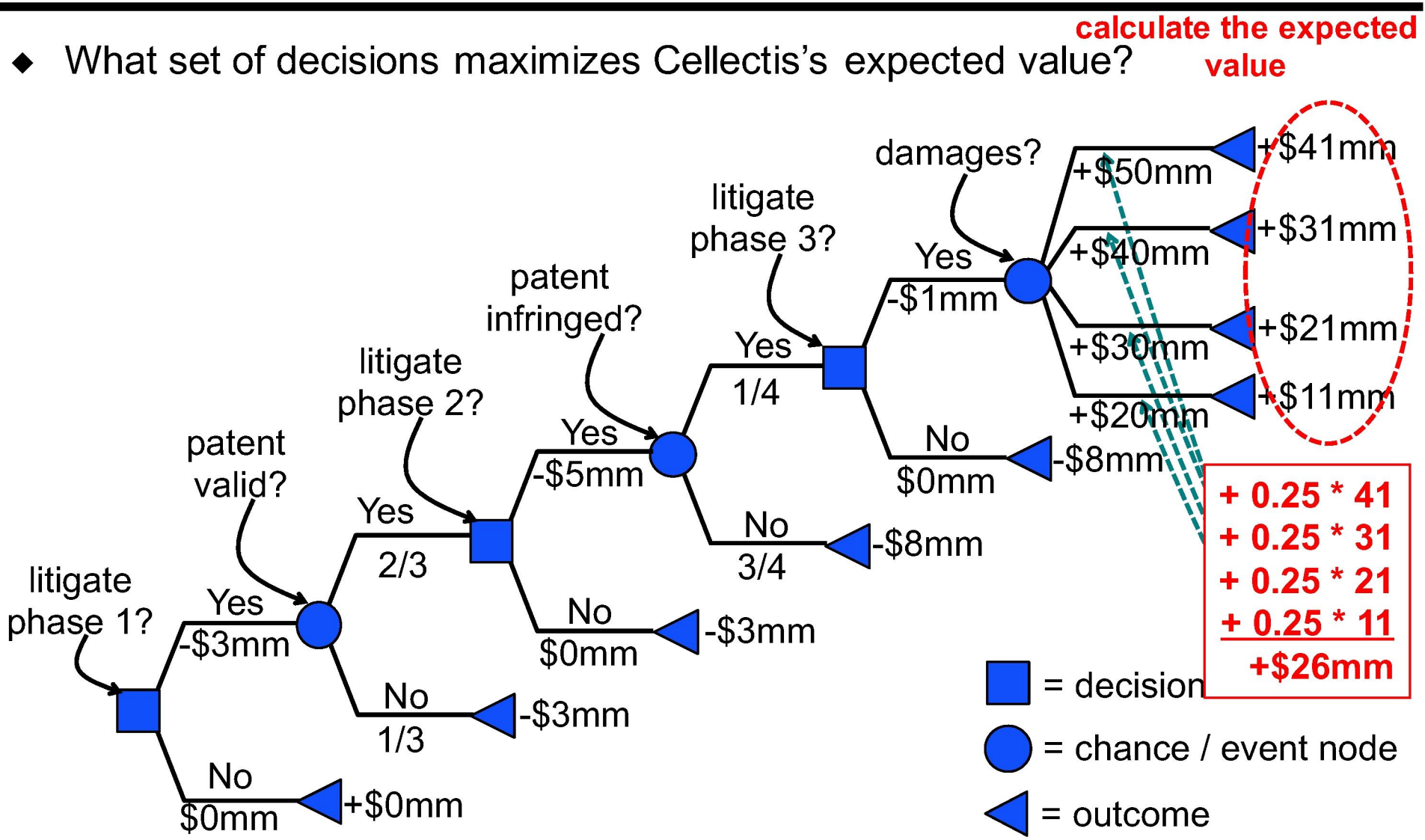

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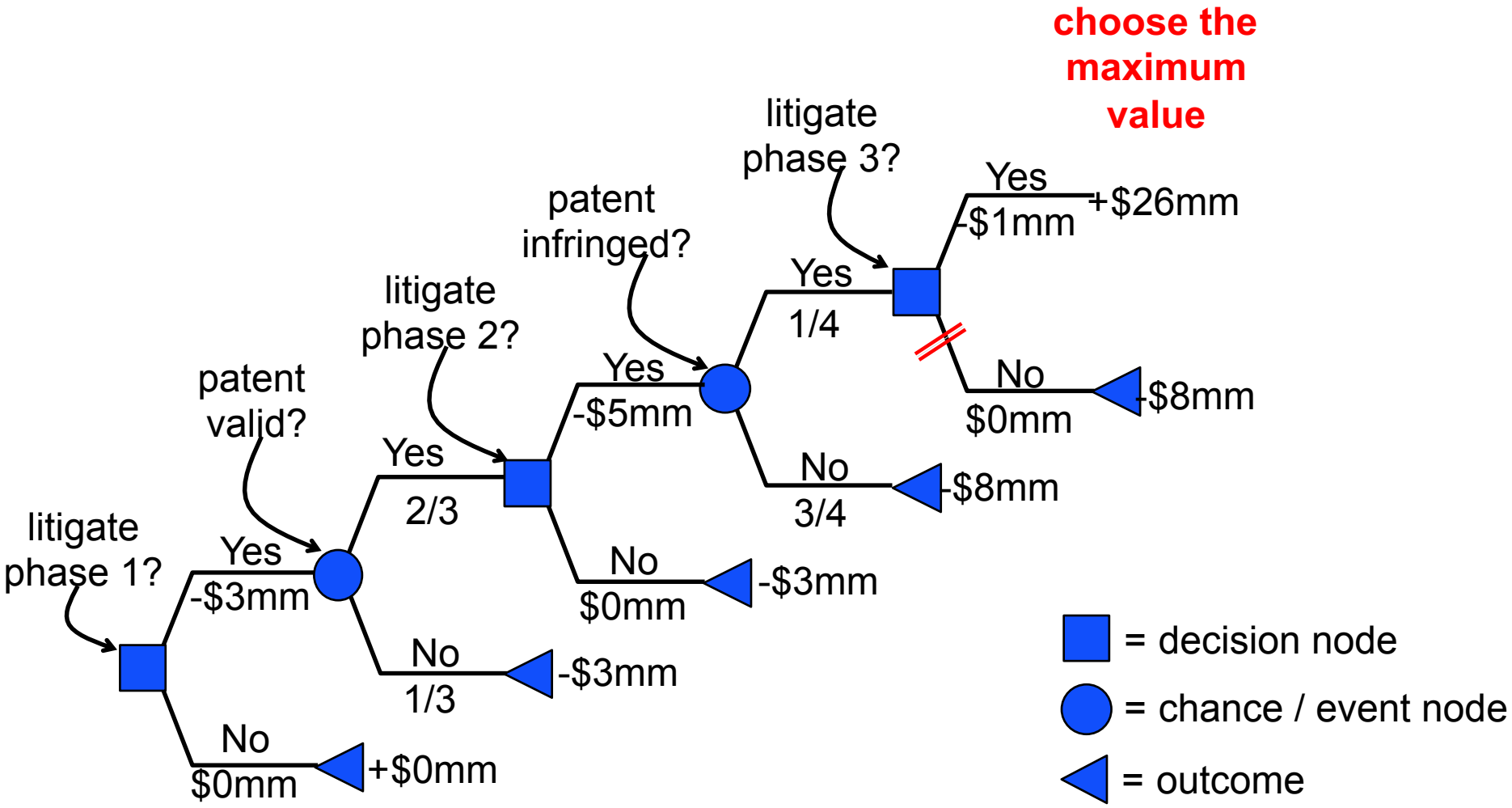

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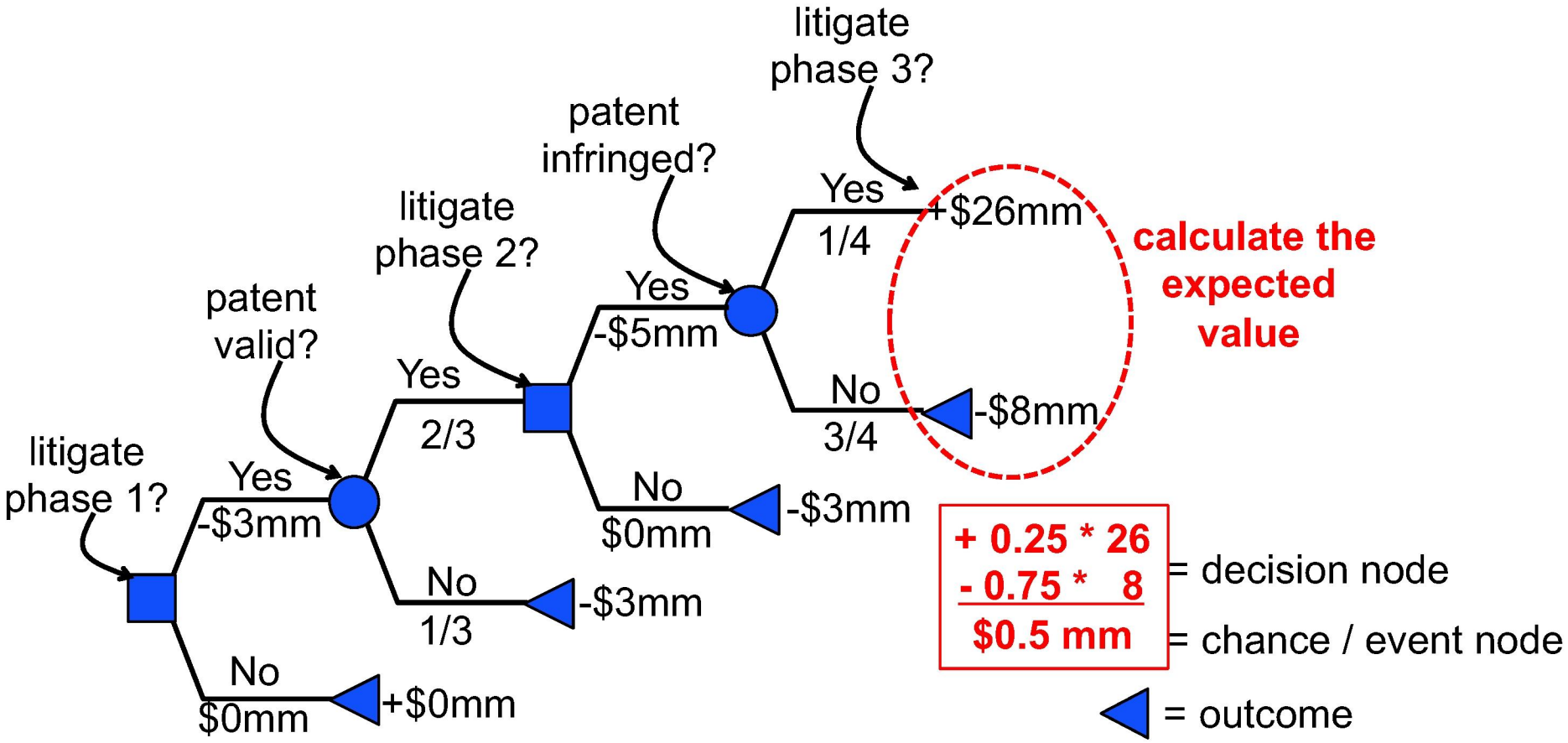

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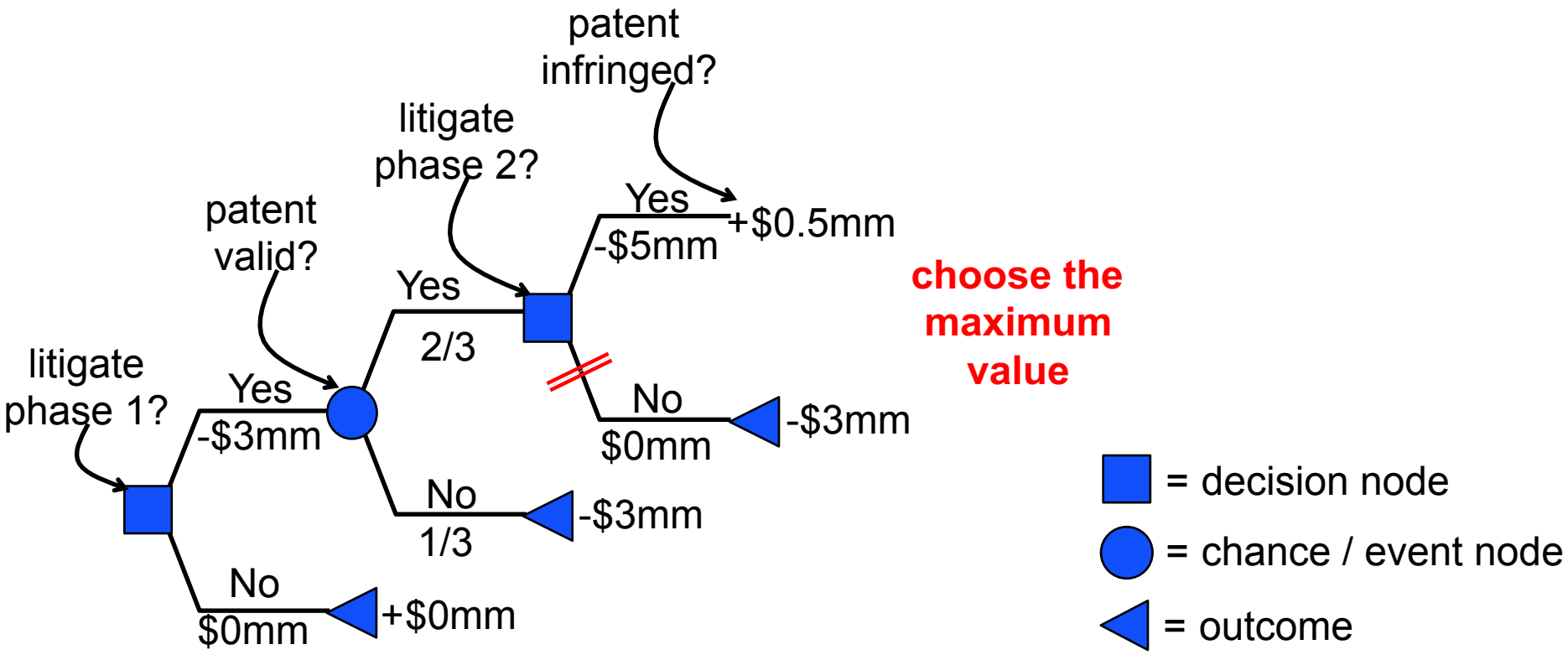

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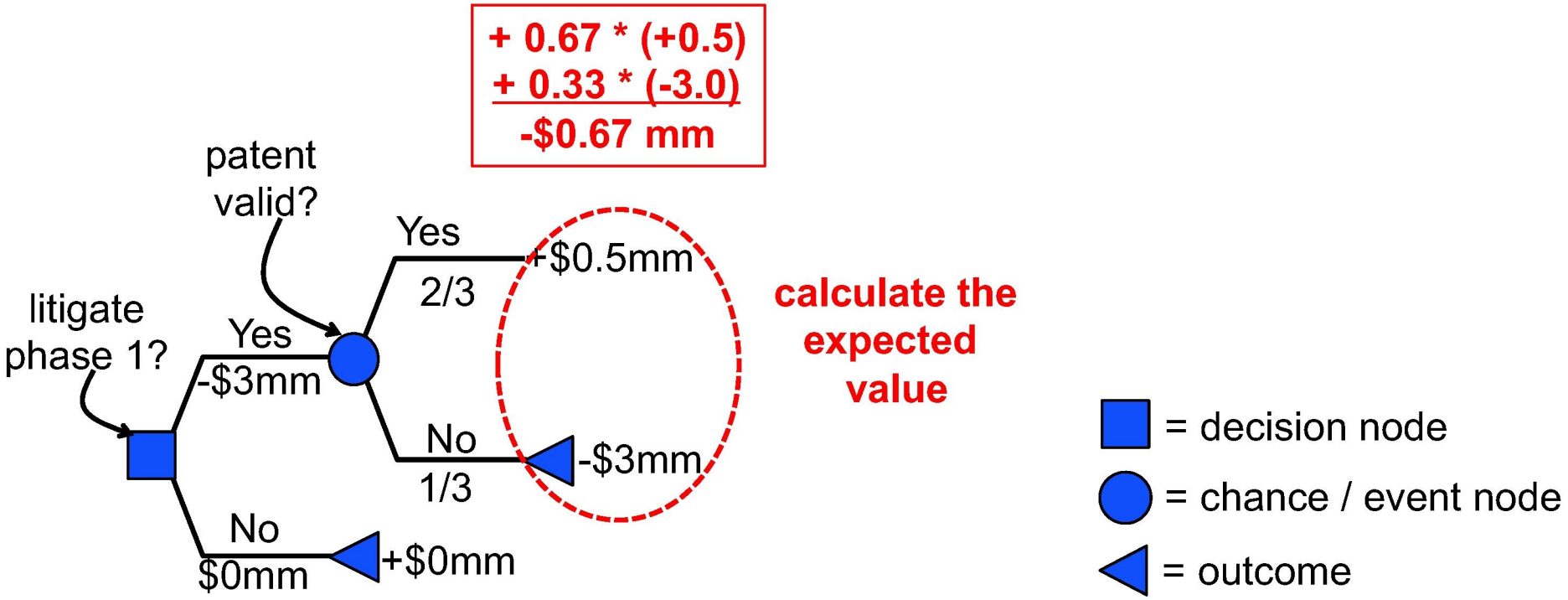

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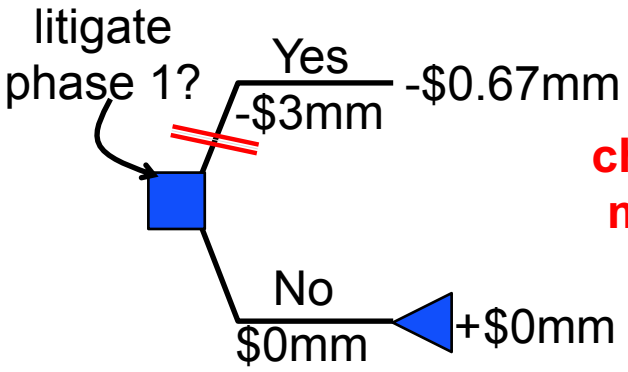
Cellectis should not enter into litigation at all.



choose the maximum value

= decision node
= chance / event node
= outcome

Results for Cellectis's decision problem

- We built a decision tree
  - Using decision nodes, event nodes, outcomes
  - Making sure that probabilities at event nodes summed to one
  - Adding up cash flows from the root to each leaf to calculate payouts
- We identified the following stratagies
  - The maxi-min, max-max, and expected-value-maximizing strategies
- The initial maxi-min and expected-value-maximizing decisions coincided
  - Do not litigate and collect $0mm
- The maxi-max strategy differed
  - To have a chance at collecting damages
  - Continue through all stages of litigation