PA 4010
Public Affairs Decision Making

SESSION 6: MODELING DECISIONS WITH DECISION TREES

THURSDAY, SEPTEMBER 5, 2024

Agenda for Today

- Minor clarification regarding PrOACT from homework
- Brief aside to connect Consequence Tables and Indifference Curves
- Intro to uncertainty
  - Ignore the math today and focus on the terminology
  - Discuss a couple common fallacies of probability
- Intro to decision trees (more on this in future classes)

PrOACT

- Pr: What is the problem
- O: Specify the objectives*
- A: Create a set of alternatives
- C: Understand the consequences of these alternatives
- T: Grapples with tradeoffs

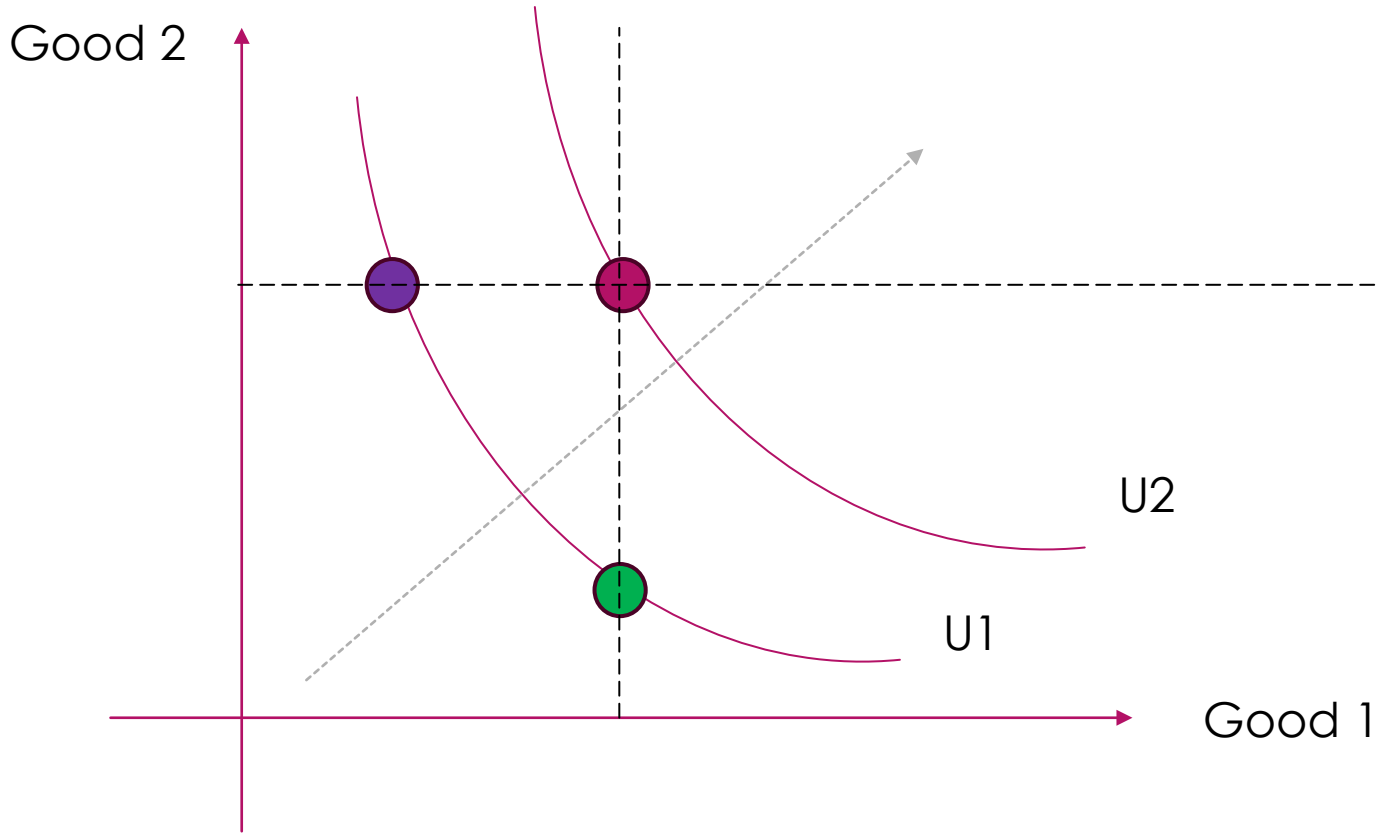
Specify the objectives

- What I saw commonly on the homework:
  - ~ What is important contextual information to keep in mind when determining alternatives?
- What I think a better representation might be:
  - ~ What are the confines of the space of alternatives? What are the "rules"?
  - ~ Are there certain restrictions that must be in place for an alternative to even be considered?
- Example:
  - **Problem**: Football team is on a losing streak and athletic director needs to re-evaluate how to get back to winning.
  - **Objects/Constraints**: (1) Increase winning, (2) Head coach is under contract for at least 5 more years, and breaking the contract is too expensive to be considered as a possible alternative → Cannot fire head coach.

Brief Aside on Indifference Curves

- A few lectures ago, I made a point that Indifference Curves are a way that economists have tried to depict rational decision making.

Brief Aside on Indifference Curves



Brief Aside on Indifference Curves

- A few lectures ago, I made a point that Indifference Curves are a way that economists have tried to depict rational decision making.
- But how does this connect to what we're learning in this class?
  - Roughly... consequence tables!

	<weights>	OSU	Miami	Kenyon
Job Prospects	50%	75	60	60
Campus Life	50%	80	90	70
Total	**100%**	**77.5**	**75**	**65**

Let's return to the question from last class… which college should you go to?

We used consequence tables to try to objectively analyze this instead of just relying on our gut or instinct.

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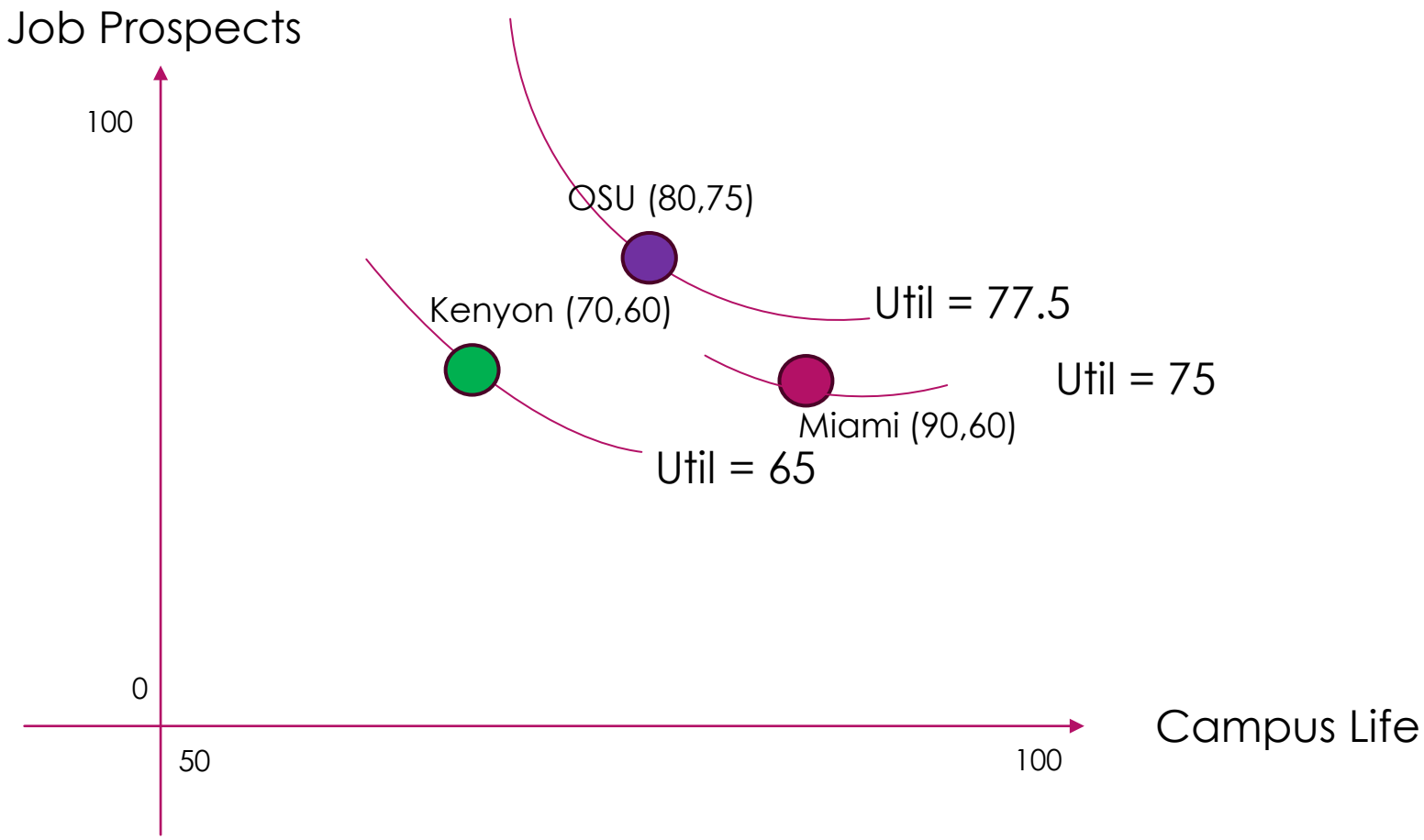

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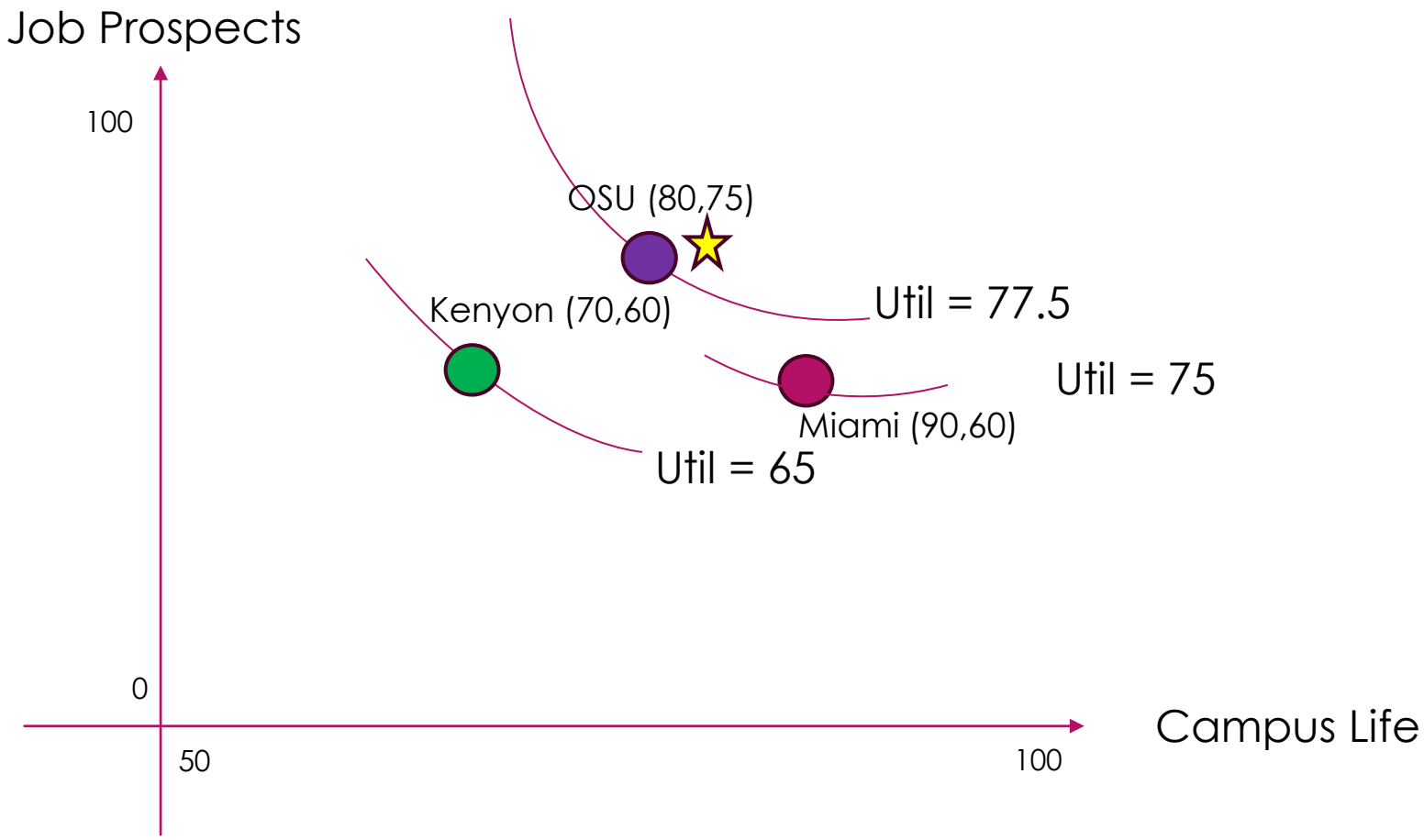

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Key points for those interested in future graduate studies...

1. A **utility function** takes a bunch of inputs (`objectives`) and transforms them in such a way that you get a single meaningful number that can be compared.
    1. Here, the **bundle of inputs** are Job prospects and Campus life.
    2. Here, our utility function **takes the average** of the two inputs and spits out a number (e.g. 77.5).
2. Now we can compare OSU, Miami, and Kenyon objectively.
3. With no constraints, we will want to choose the one that makes us happiest! So we choose to go to OSU.

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- The major simplification that we made is that the decision maker knows every objective for every alternative with absolute certainty.
  - You were given a formula to calculate exactly how much money you would earn over the next 40 years when you were constructing your matrix.
  - Is this a reasonable simplification? Why? Why not?

Consider the earnings of two different schools:

Military Academy:

Lowest earnings graduates: $45,000

Highest earning graduates: $55,000

Mean earnings: $50,000

Art School:

Lowest earnings graduates: $10,000

Highest earning graduates: $90,000

Mean earnings: $50,000

Both earn $50,000 on average, but which would you rather go to (based purely on earnings)?

As it relates to public policy

Country A:

Bottom 50% of earners: 12-13% of total income

Top 10% of earners: >50% of total income

Mean income: $76,000

Country B:

Bottom 50% of earners: 30-35% of total income

Top 10% of earners: 20-20% of total income

Mean income: $76,000

If you're a child being born into a family from one of these countries, the average income is about the same. But you're much more likely to be born into a poor family in country A than you are in country B.

Uncertainty

Def'n: Uncertainty: a situation in which the future is unpredictable, and a decision must consider the probability of several outcomes.

Scenario: You are purchasing a house an investment, and the two options are on the coast of North Carolina for $1M or inland North Carolina for $500,000. You know that the value of the homes will appreciate and you can sell for $1.2M, and $690,000, respectively.

Certainty: All else equal, if this is purely for investment, you will make $200,000 > $190,000 so you should buy the coastal home.

Uncertainty: In reality, there is a 15% chance that your coastal home will be destroyed by a hurricane before you sell it, and so your expected earnings from the home are: 0.85*(200,000) + 0.1*(1) = $170,000. So you should buy the inland home.

Expected Outcome

An expected outcome is the sum of the outcomes under different outcome states (scenarios). You don't know the true outcome, so you act as though any of the outcomes could happen.

State	1	2	3	4	5	6	7	8	9	10
Outcome	Fine	Fine	Fine	Disaster	Fine	Fine	Fine	Fine	Fine	Fine
Earnings	200K	200K	200K	0	200K	200K	200K	200K	200K	200K

→ 9 out of 10 times, your house is fine, BUT 1 out of 10 times, your house is destroyed. So your "average" earnings across all 10 scenarios is $\frac{9*(200{,}000)+1*(0)}{10} = \$180{,}000.$

Example 1

- You and your husband/wife really want a daughter. So far, you've had 5 children… all boys. You're pregnant again.

- Q: Are you more likely to have a boy or a girl next?
- Q: What probability is it that your next child will be a girl?

Example 2

- Your aunt plays the lottery every week. She keeps tedious detailed information about which lotto balls are picked each evening. Over the last 1,000 days, the distribution of balls has been…

Ball	0	1	2	3	4	5	6	7	8	9
Outcome	100	90	110	50	101	98	150	125	82	94

- Q: Which ball would you pick?

Example 3 [example generated by ChatGPT]

- Linda is a 31-year old woman who is single, outspoken, and very bright. She majored in public policy and was actively engaged in the campus student group called Eco-Peace.
- Q: Which is more likely?
  a. Linda is a bank teller; or
  b. Linda is a bank teller and an environmental activist.

Common probability fallacies…

- **Gambler's fallacy** (independent events are not shaped by past outcomes)
- **Mean reversion fallacy** (in small samples, the average does not always occur)
- **Hot hand fallacy** (hot streaks don't affect the outcome of random events)
- **Sunk cost fallacy** (past resource investment doesn't always shape the future)
- **Cluttering illusion** (patterns may show up where they don't exist [stock market?])
- **Conjunction fallacy** (the probability of the intersection of two events is never greater than the probability of each event occurring by itself).

Risk preferences: Which would you pick?

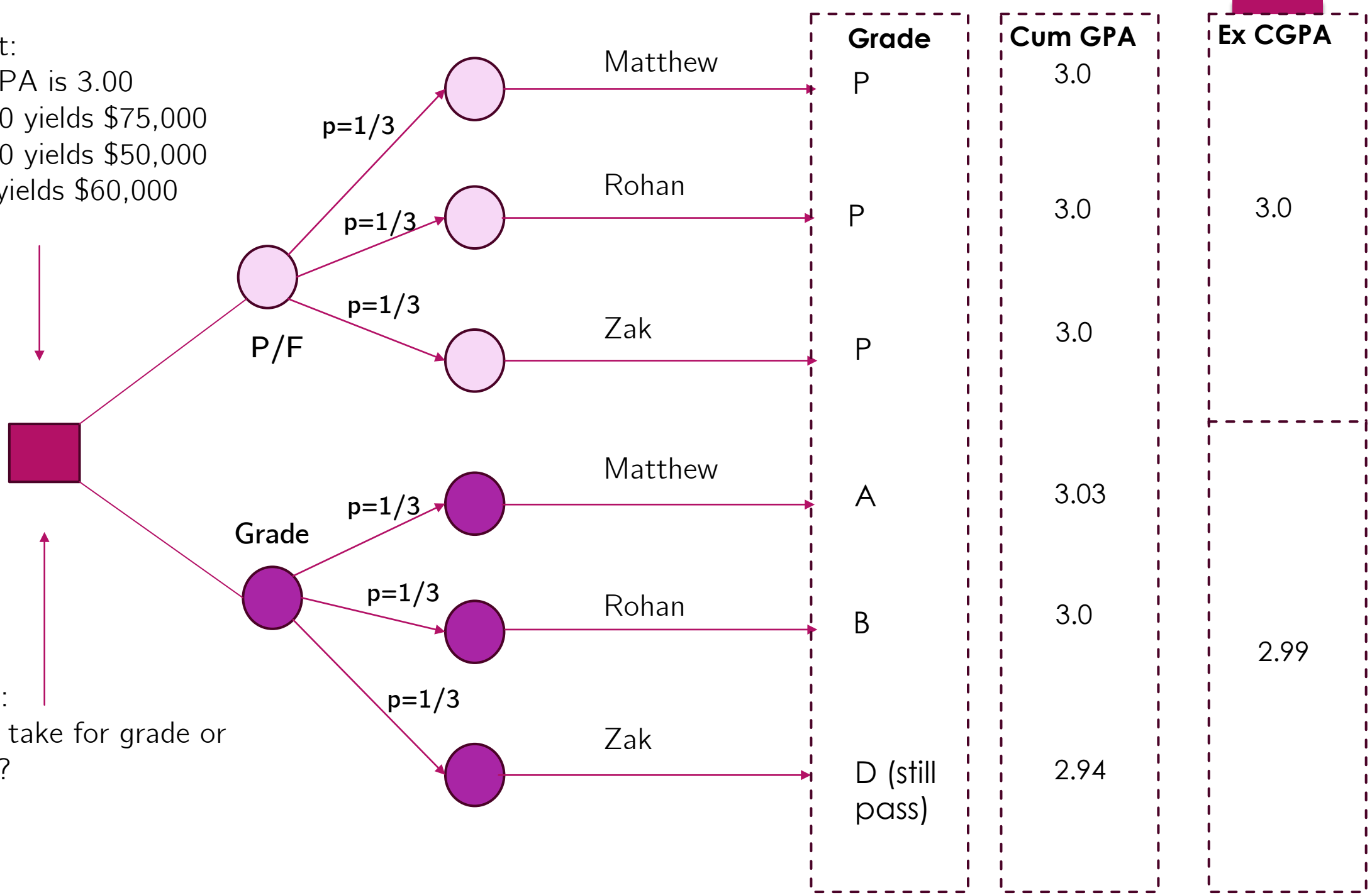
- You inherit $100,000 from a long-lost relative. You decide that this is a great opportunity to invest this money for the future (20 years).
- **Option A**: You have the opportunity to franchise a Chik-Fil-A. This is essentially no risk, and you'd make $100,000/year (or $2M total).
- **Option B:** A startup company comes to you and asks you to invest $100,000 in their company for 50% of all the earnings. There is a 90% chance that this company fails, and you lose all your inheritance, but a 10% chance that it succeeds. If it succeeds, it will earn $2M per year, meaning that you'd expect to earn $2M (the same) after 20 years.

Risk preferences: Which would you pick?

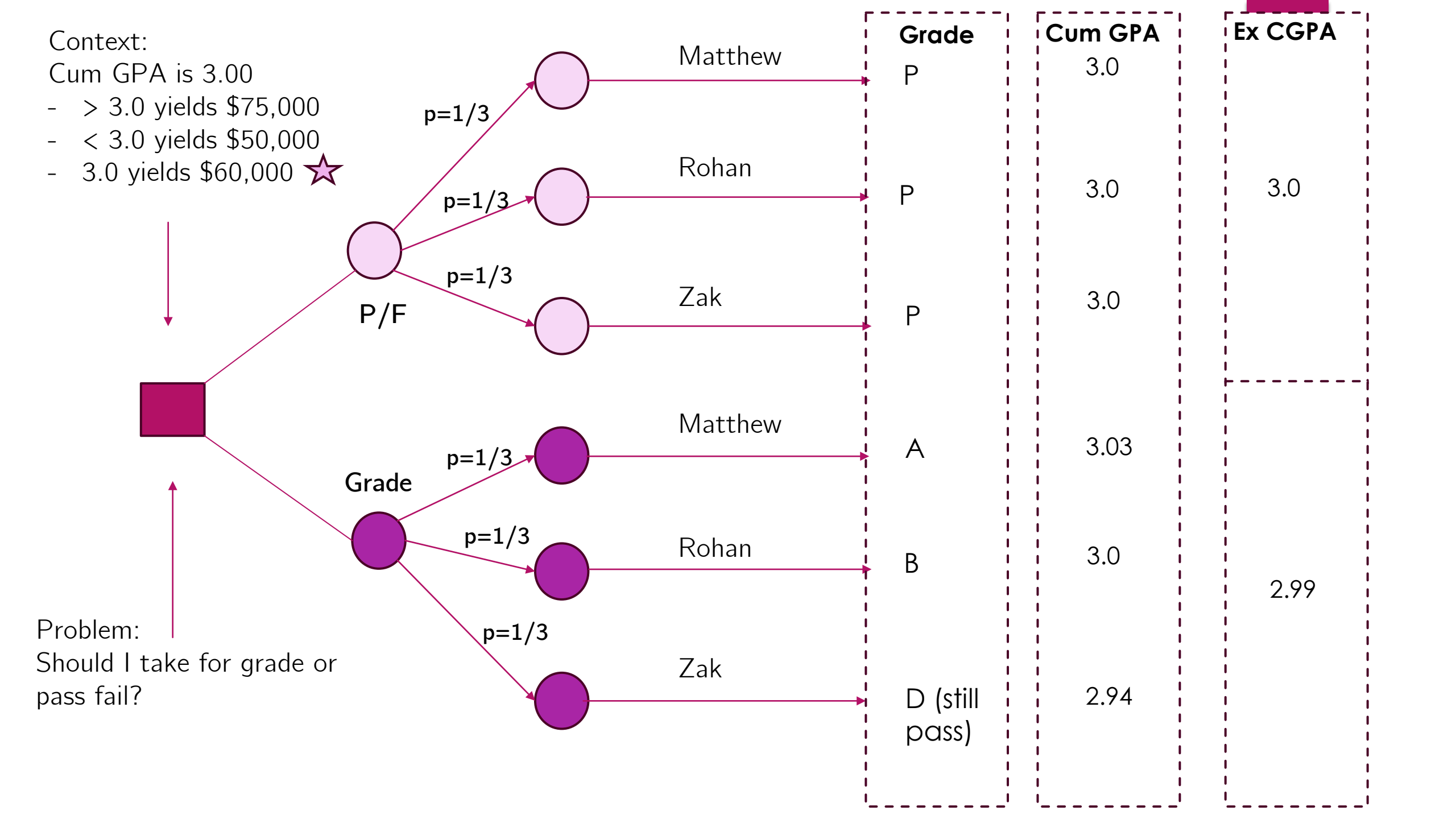
- **Risk Loving**: You prefer riskier scenarios. High risk and high return is more important than low risk and average return.
- **Risk Averse:** You hate risk. Any amount of risk taints your decision to choose an outcome.
- **Risk Neutral:** You're a computer. You just pick whatever makes more sense.

Intro to decision trees

Context:
Cum GPA is 3.00
- > 3.0 yields $75,000
- < 3.0 yields $50,000
- 3.0 yields $60,000



Problem:
Should I take for grade or pass fail?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- 3.0 yields $60,000
P/F
p=1/3
p=1/3
p=1/3
Matthew
Rohan
Zak
Grade
p=1/3
p=1/3
p=1/3
Matthew
Rohan
Zak
Problem:
Should I take for grade or pass fail?
Grade
P
P
P
A
B
D (still pass)
Cum GPA
3.0
3.0
3.0
3.03
3.0
2.94
Ex CGPA
3.0
2.99