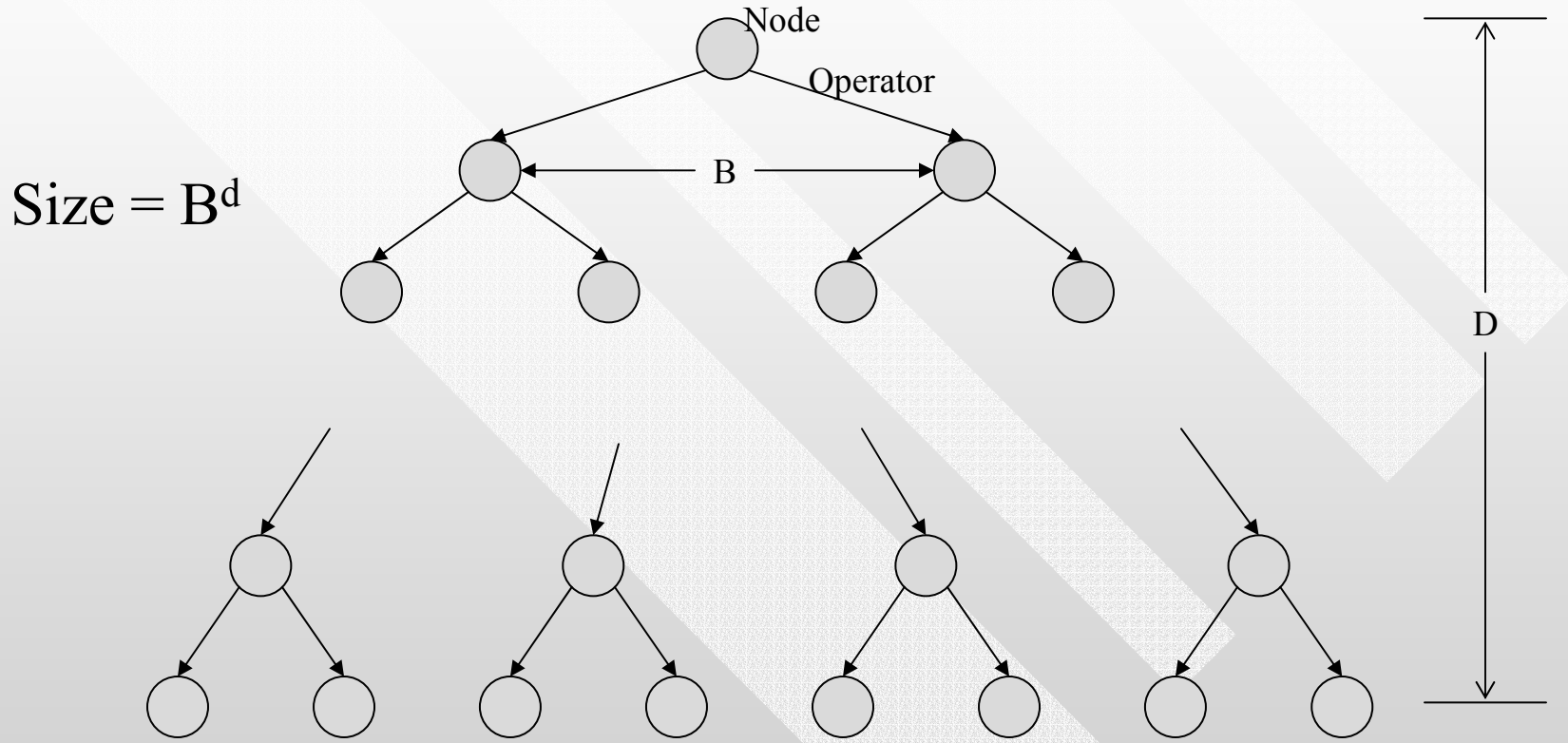
Search Basics

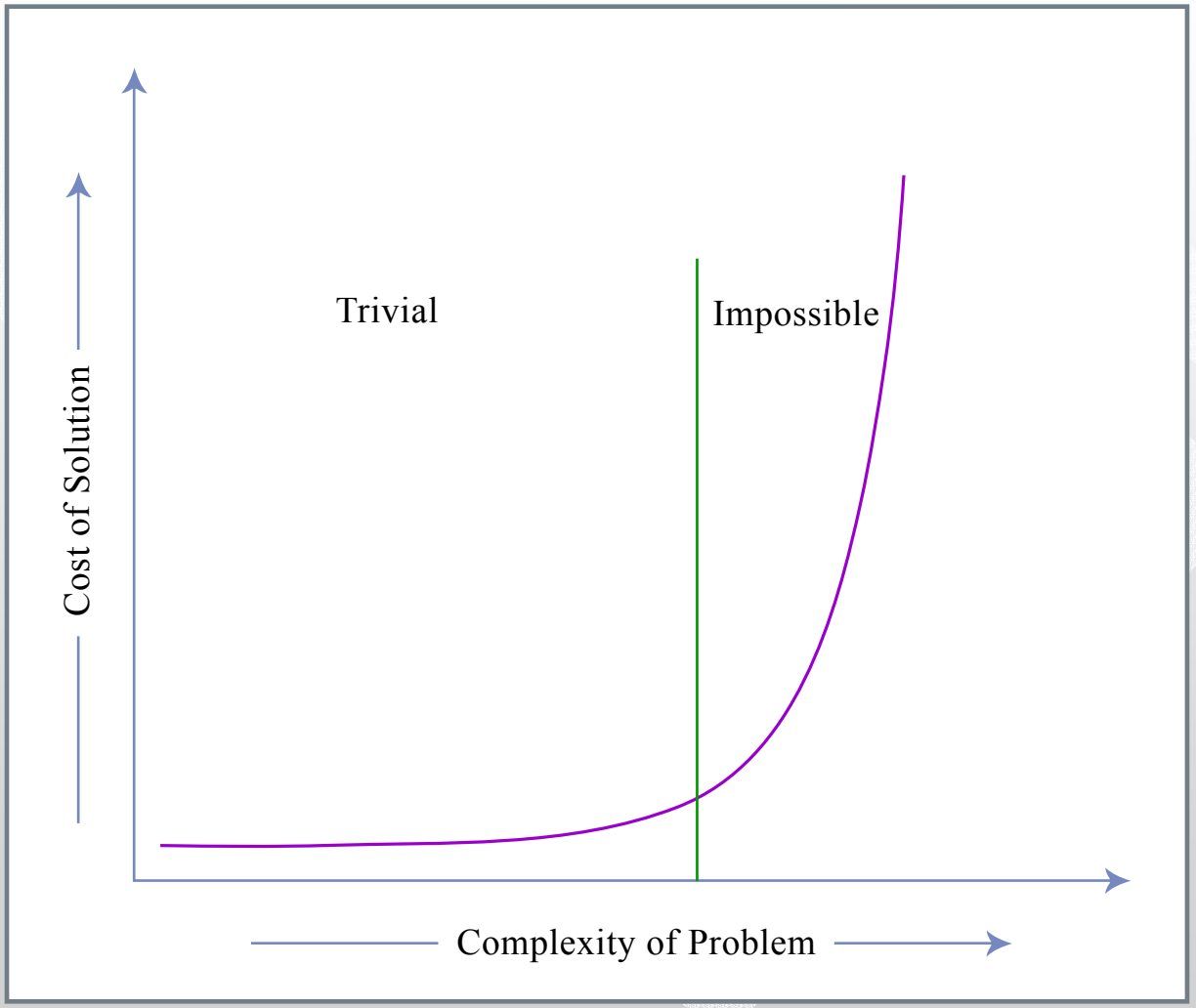
- Lecture 2, Part 2.

The Fundamental Problem: Search in a Problem Space



- B = branching factor
- D = depth

Search Spaces Grow Exponentially

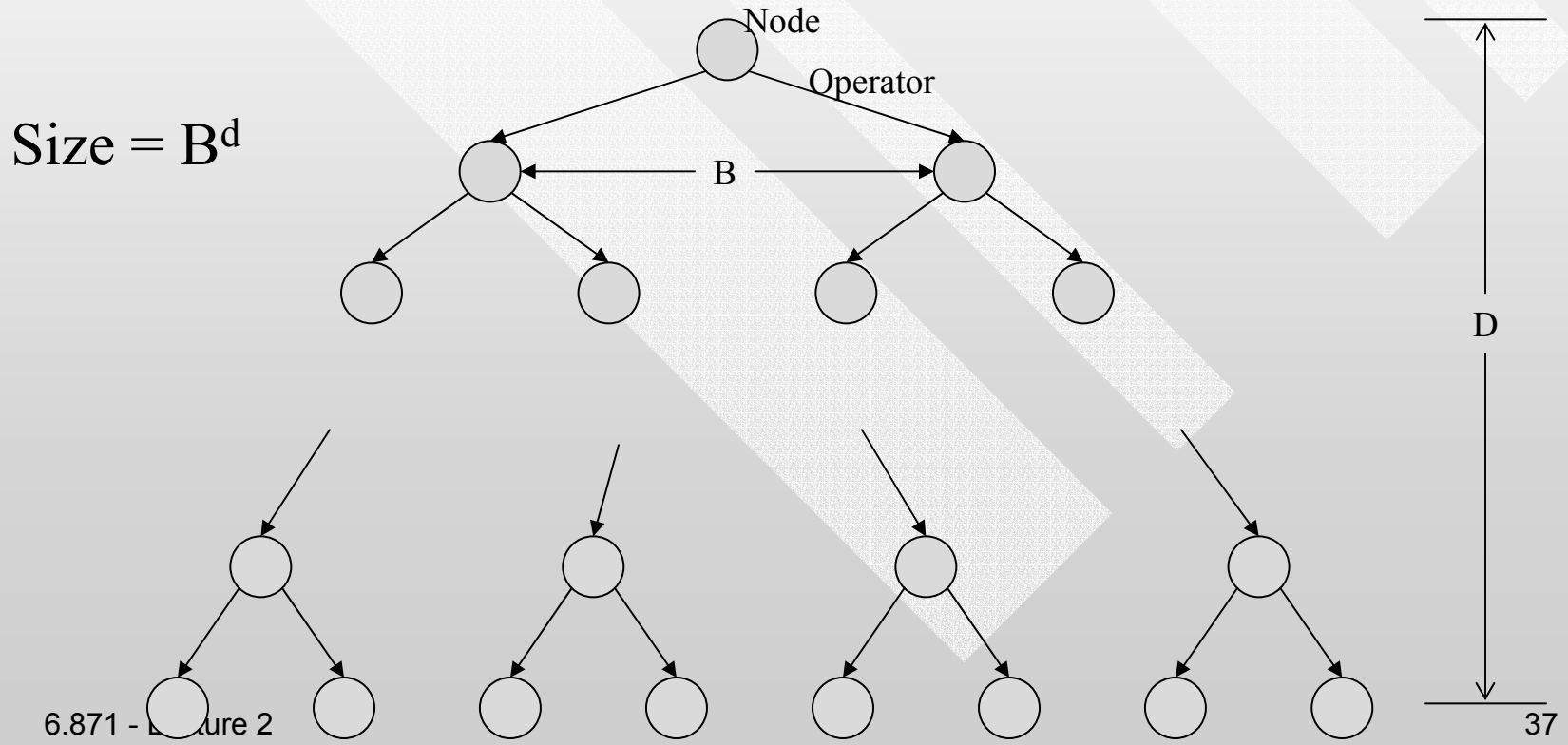


The marginal cost of slight improvement is prohibitive

Figure by MIT OCW.

The Shape of The Space

- How densely distributed are the answers?
- How uniformly distributed are the answers?
- How do answer quality and distance relate?



Depth First Search

- Go down before you go across
- Maintains focus
- Minimizes storage requirements
- Finds answer faster sometimes

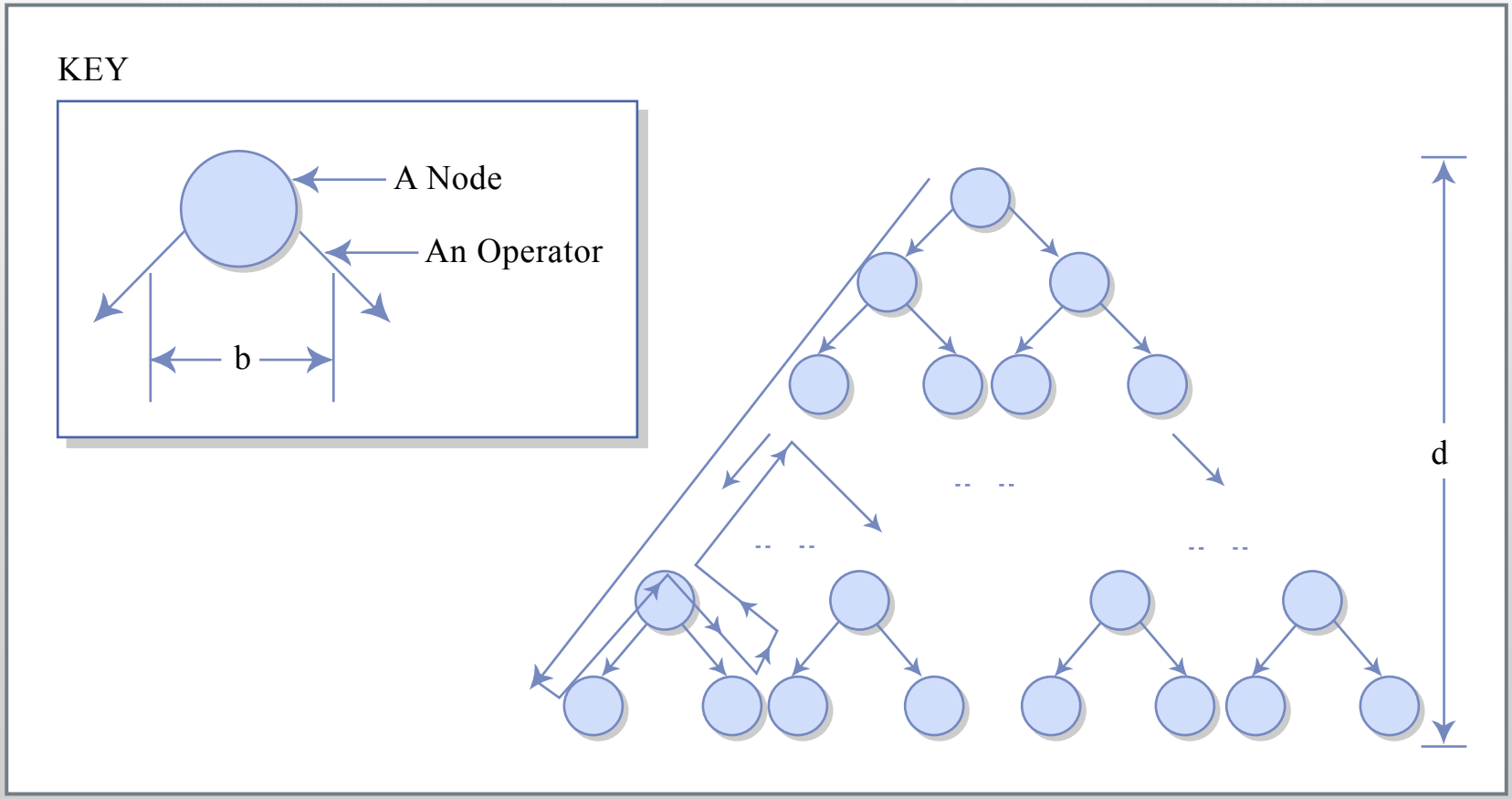
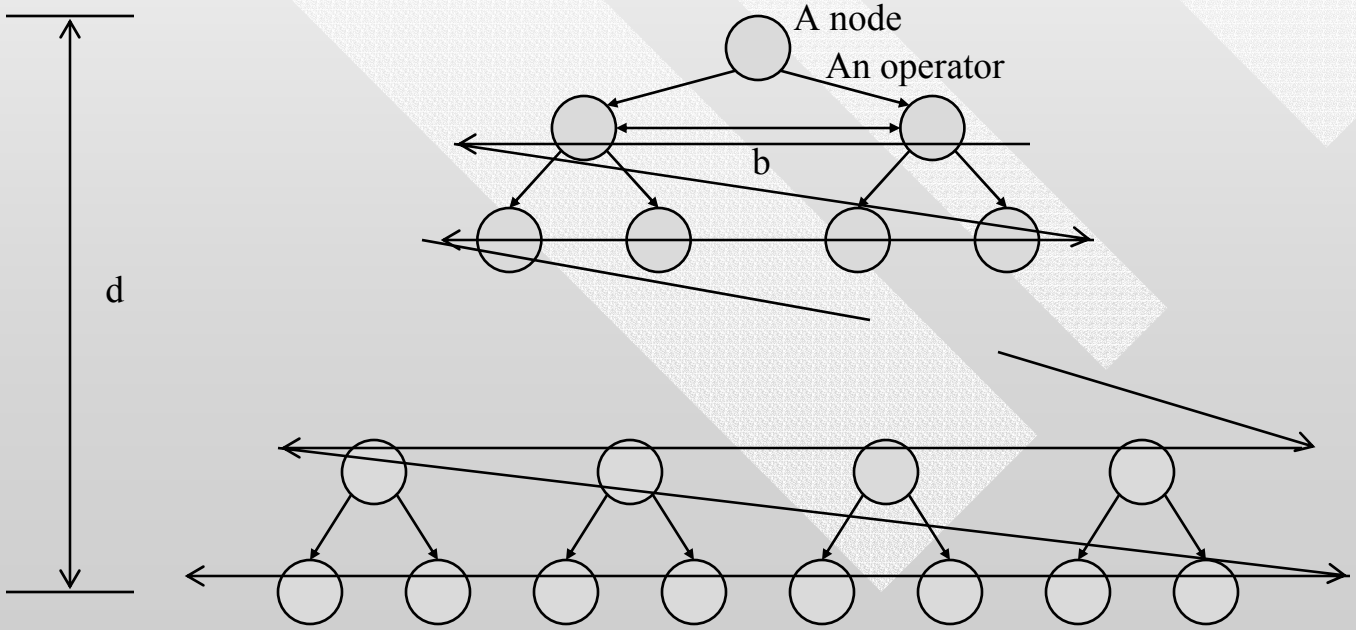


Figure by MIT OCW.

Breadth First Search

- Never gets lost on deep or infinite path
- Always finds answer if it's there
- Requires lots of storage



Best First Search

- Requires quality metric
- If metric is informed it's very quick
- Space requirements are intermediate

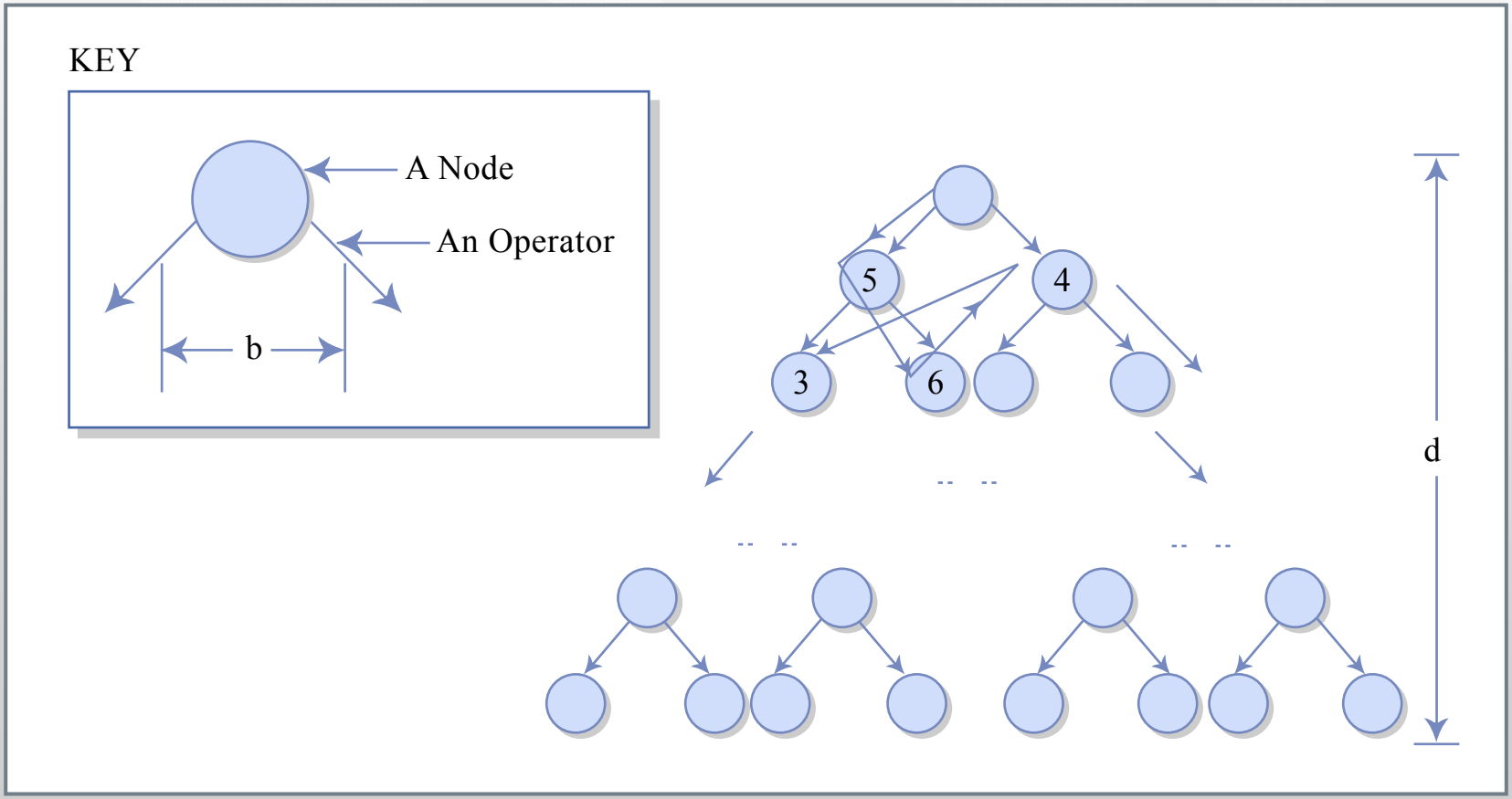


Figure by MIT OCW.

Pruning

- Throw away unpromising nodes
- Some risk that the answer is still there
- Great savings in time and space
- Breadth limited search, beam search

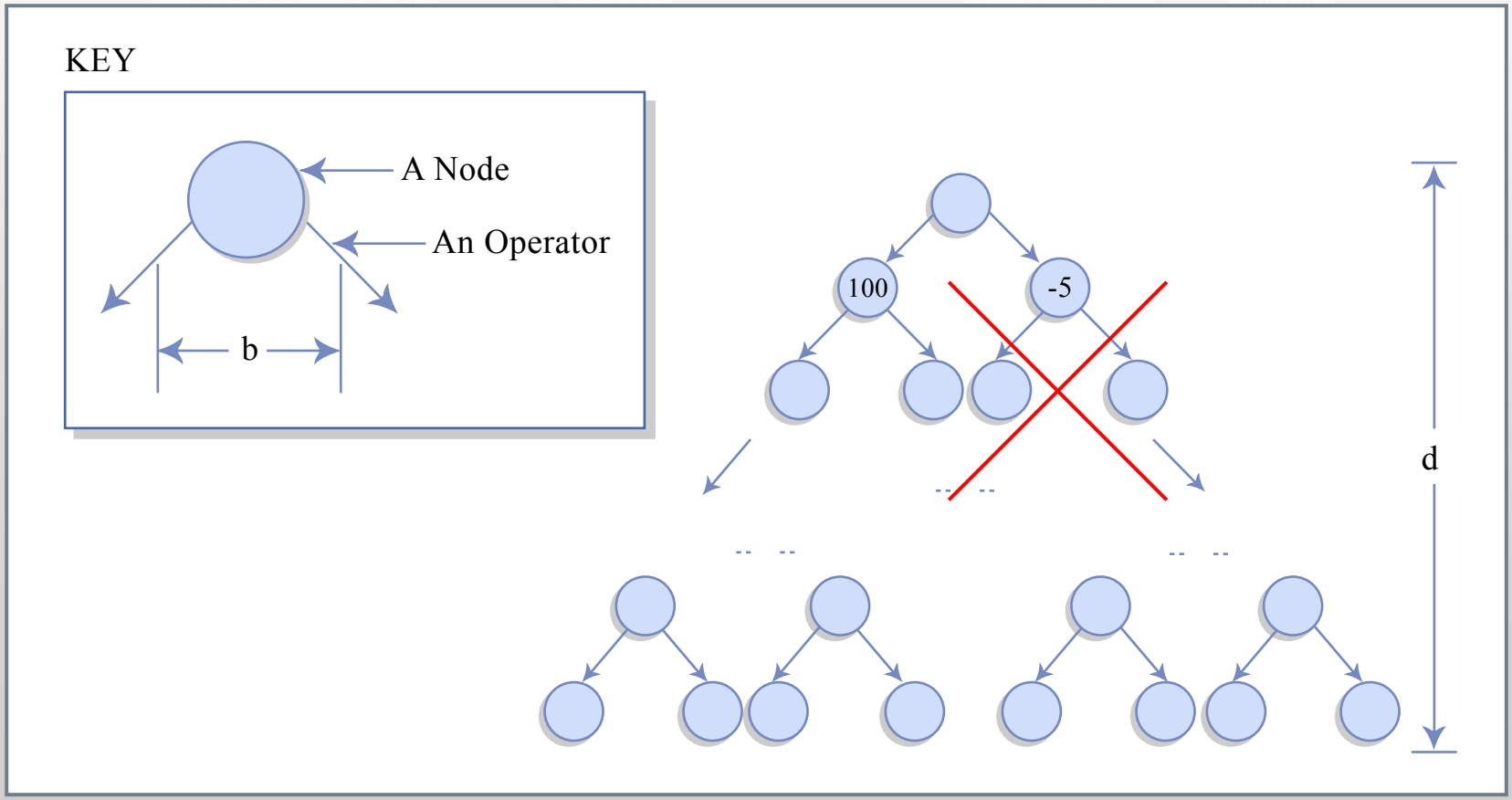


Figure by MIT OCW.

Optimum Often isn't Optimum

- In the real world things go wrong
- Robust near-optimum is usually better on average

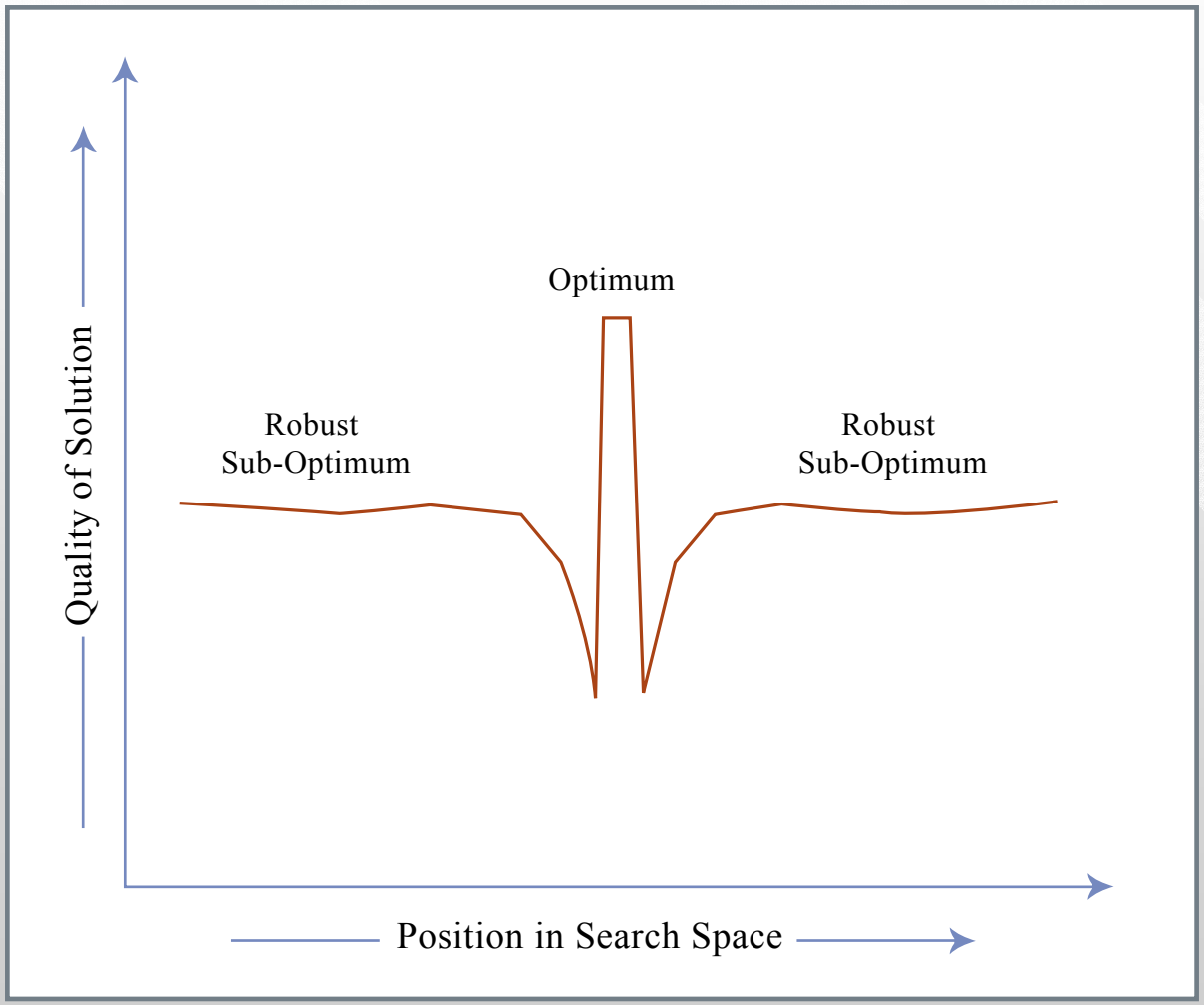
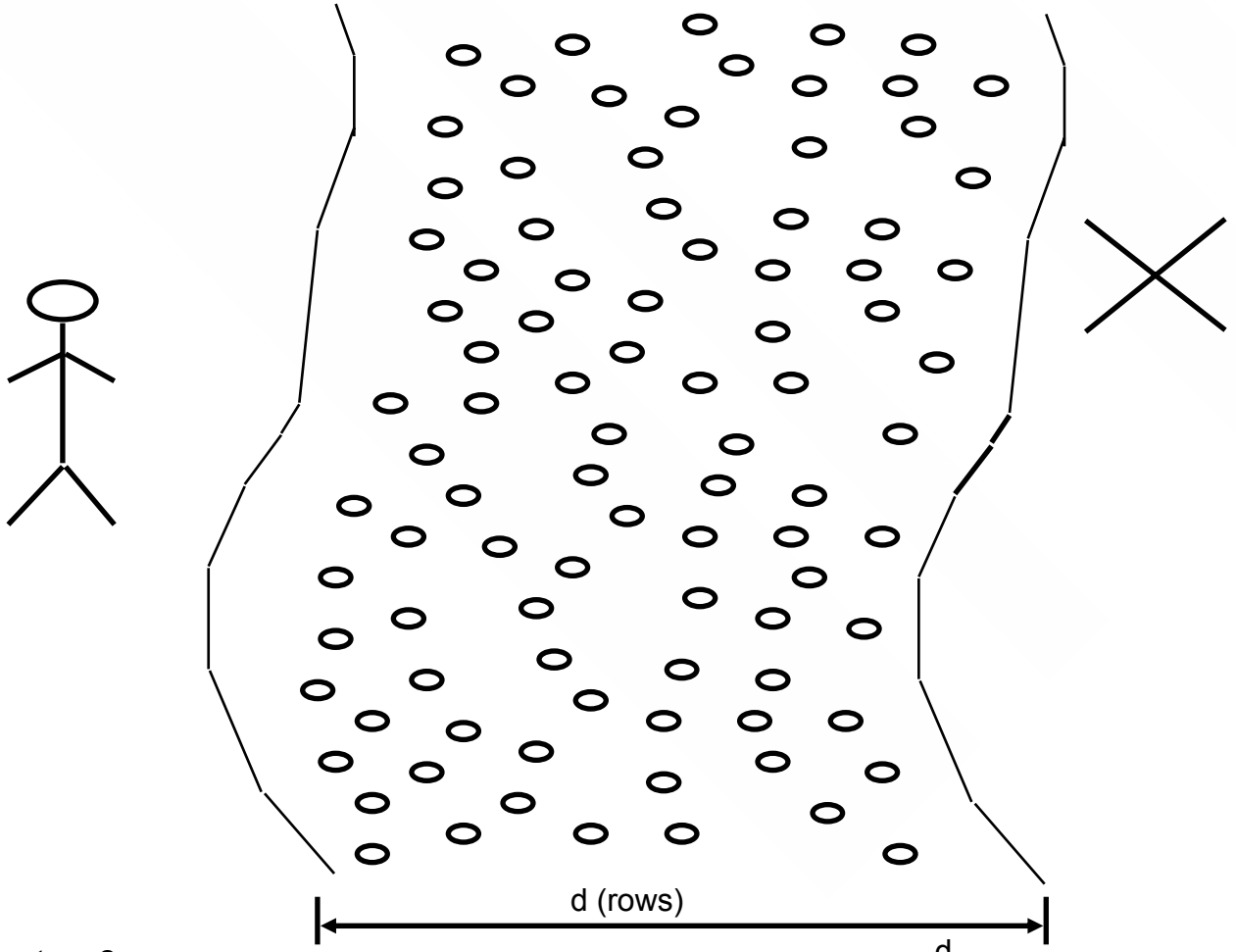


Figure by MIT OCW.

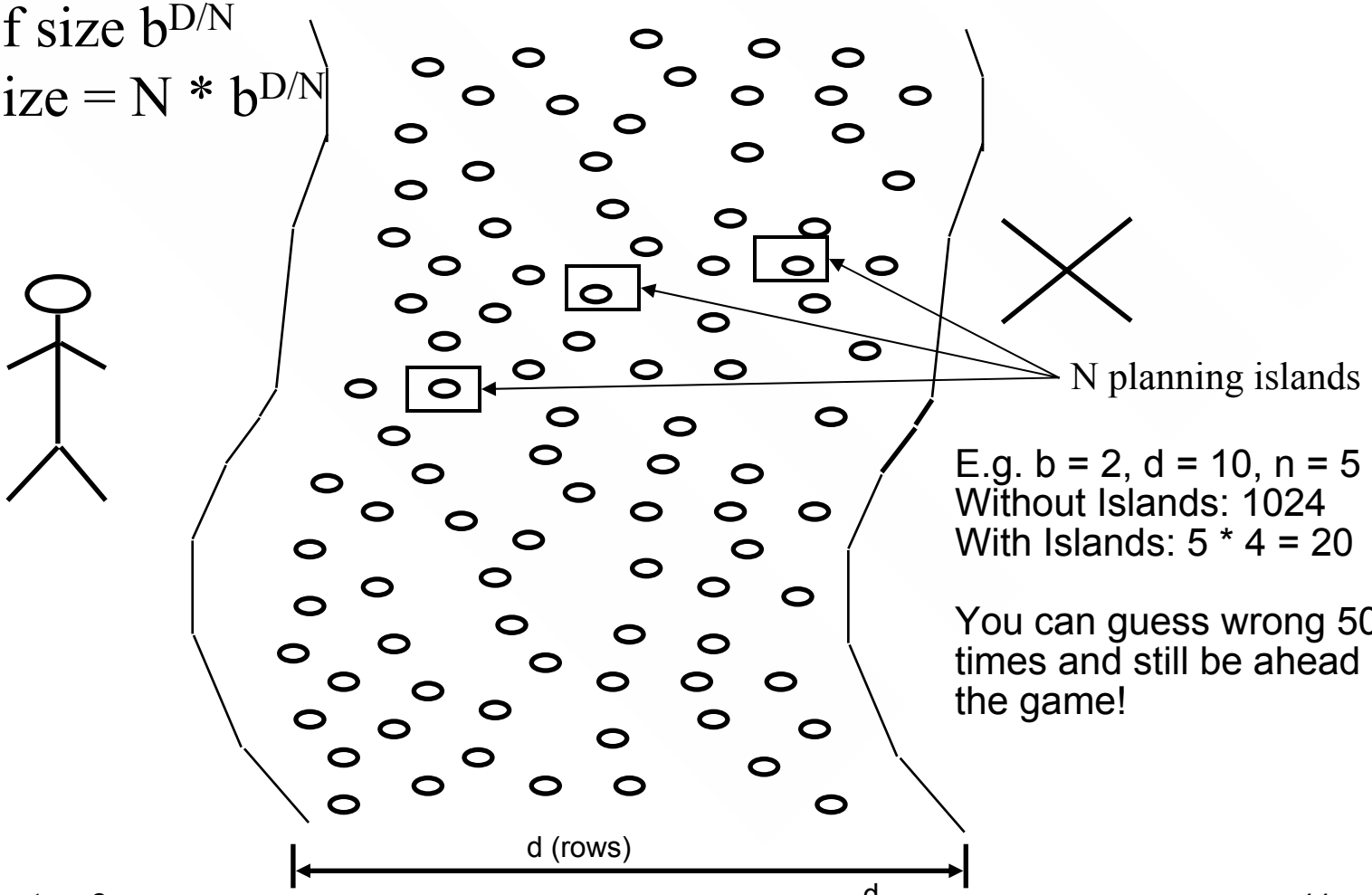
Planning Islands: The Power of Recognition



Problem complexity = b

Recognizing the Form of the Problem

N subproblems
Each of depth D/N
Each of size $b^{D/N}$
Total size = $N * b^{D/N}$



E.g. b = 2, d = 10, n = 5
Without Islands: 1024
With Islands: 5 * 4 = 20

You can guess wrong 50 times and still be ahead of the game!

Summary

- All problem solving problems involve search spaces
- Search space grow intractably
- Many common algorithms for search are known

- In the Knowledge Lies the Power
  - Knowledge of a heuristic metric
  - Knowledge of planning islands
  - Knowledge of relevant abstractions
- Build representations that capture these sources of power

Version 2

```
INTEGER DEGREE, COEFF, EXPON
REAL ARRAY PROBLEM, ANSWER [1:2, 1:1000]
EXPON = 1
COEFF = 2
This version reads in a line of pairs of integers,
   coefficients and exponents, putting the coefficients
   in the COEFF row of P and the exponents in the EXPON
   row of P. Example:
```

$$3x^3 + 4x^2 + 5x + 7$$

```
results in EXPON row: 3 2 1 0
           COEFF row: 3 4 5 7
```

Version 2

```
PROCEDURE POLY-DIFF (REAL ARRAY PROBLEM)
FOR I = DEGREE TO 1 STEP -1 DO
 BEGIN
 ANSWER [COEFF, I] = PROBLEM [EXPON, I] *
                     PROBLEM [COEFF, I]
 ANSWER [EXPON, I] = PROBLEM [EXPON, I] - 1
 END
```

But What About:

sin(x)
cos(x)

sin(x) + cos(x)

*sin(x) * cos(x)*

The Checkbook Example

		Cleared Deposits	Cleared Checks	Uncleared Deposits	Uncleared Checks
Bank Balance	$1234.56	$100.00	$213.40	$250.00	$12.34
		$250.00	$874.30	$95.00	$19.99
Total uncleared		$75.00	$19.00	$180.00	$25.00
deposits	$725.00	$90.00	$22.00	$200.00	$72.54
Total uncleared				$15.00	$105.00
checks	$248.87				$14.00
					$24.00
New Balance	**$1,710.69**				