Final Examples

Announcements

Trees

Tree-Structured Data

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```
def tree(label, branches=[]):
    return [label] + list(branches)

def label(t):
    return t[0]

def branches(t):
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def is_leaf(t):
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Tree processing often involves recursive calls on subtrees

Tree Processing

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than all labels of their ancestor nodes.

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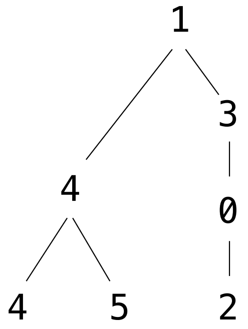

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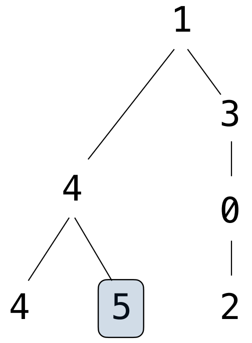

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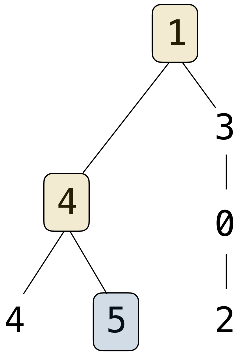

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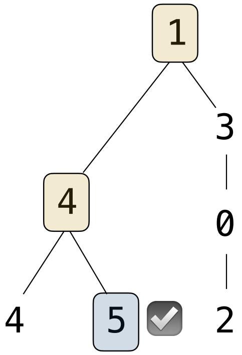

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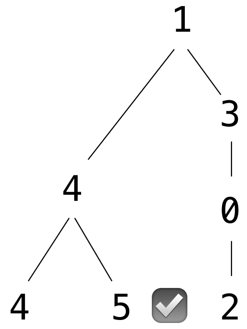

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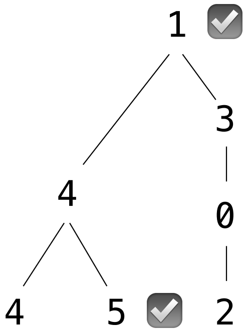

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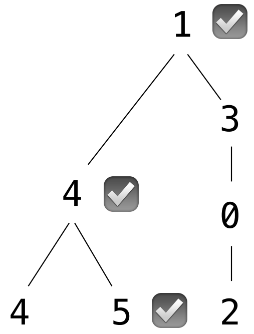

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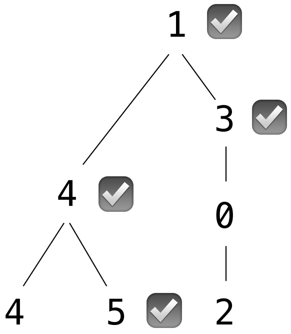

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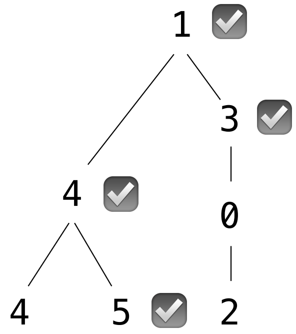

The root label is always larger than all of its ancestors

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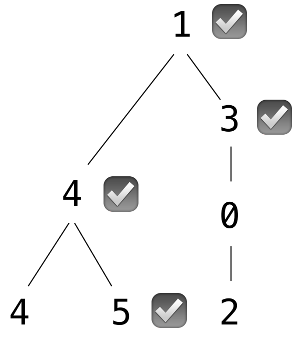

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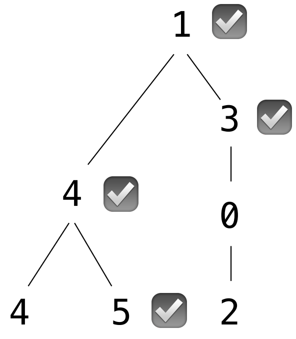

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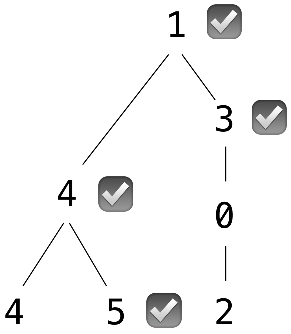

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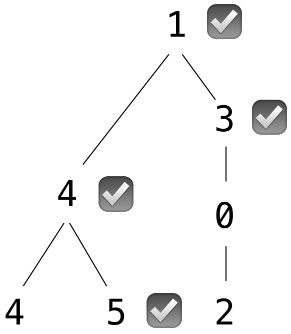

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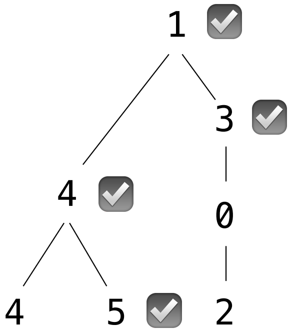

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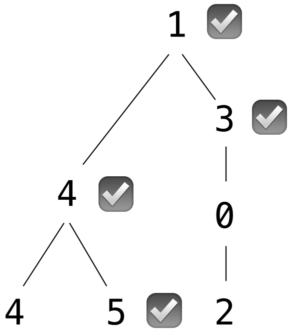

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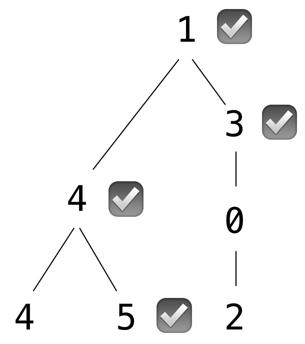

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Somehow track the largest ancestor

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        if _____________________________________________________:

            return 1 + __________________________________________

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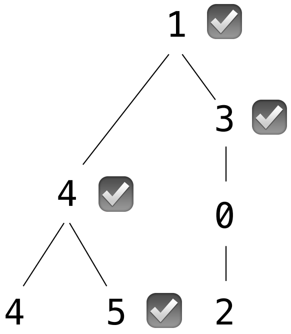

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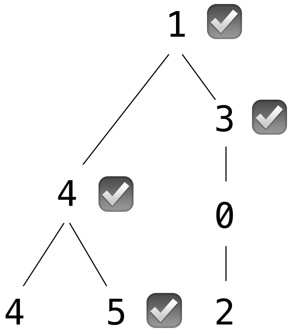

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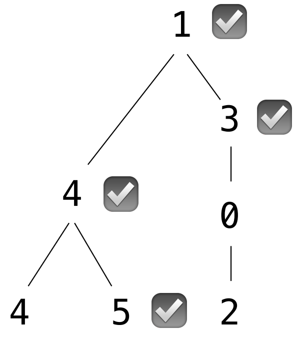

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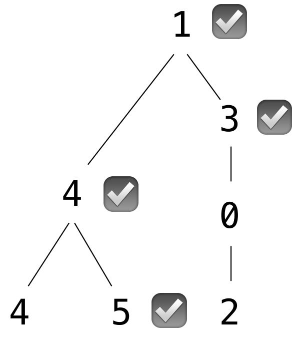

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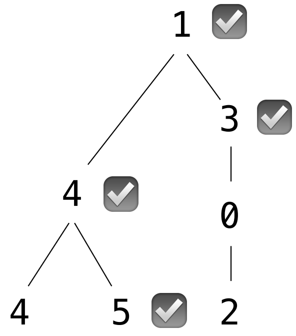

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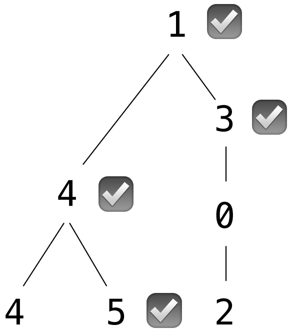

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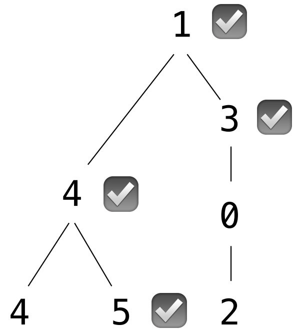
Some initial value for the largest ancestor so far...



Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors.

    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x ____________________________________:

            return 1 + ____________________________________

        else:

            return ____________________________________

    return f(t,            )_______________________________
```

Somehow track the largest ancestor

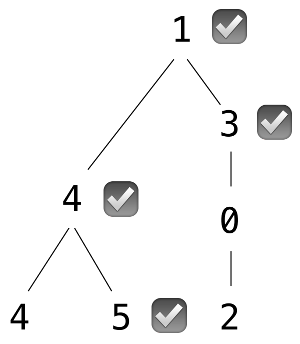
A node in t

max_ancestor

node.label > max_ancestors

Somehow increment the total count

Some initial value for the largest ancestor so far...



Solving Tree Problems

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    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x ______________________________________:

            return 1 + sum([f(b, a.label) for b in a.branches])

        else:

            return _________________________________

    return f(t,            ) ______________________________
```

Somehow track the largest ancestor

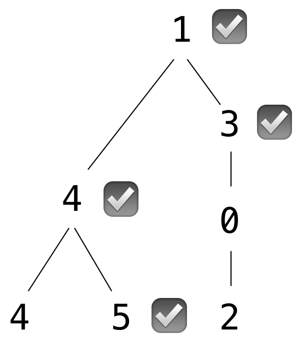
A node in t

max_ancestor

node.label > max_ancestors

Somehow increment the total count

Some initial value for the largest ancestor so far...



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    4
    """
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        if a.label > x                                  :

            return 1 + sum([f(b, a.label) for b in a.branches])

        else:

            return     sum([f(b, x) for b in a.branches])

    return f(t,           )
```

A node in t → a

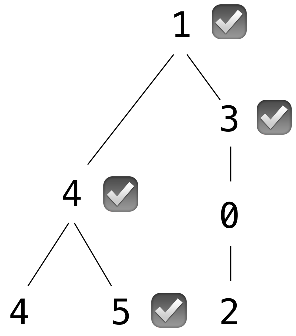
max_ancestor → x

Somehow track the largest ancestor

node.label > max_ancestors

Somehow increment the total count

Some initial value for the largest ancestor so far...



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            return 1 + sum([f(b, a.label) for b in a.branches])

        else:

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    return f(t,             )
```

Somehow track the largest ancestor

A node in t

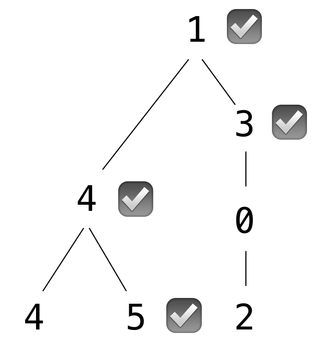
max_ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

Some initial value for the largest ancestor so far...



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    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
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        if a.label > x:
            return 1 + sum([f(b, a.label) for b in a.branches])
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            return sum([f(b, x) for b in a.branches])
    return f(t, t.label - 1)
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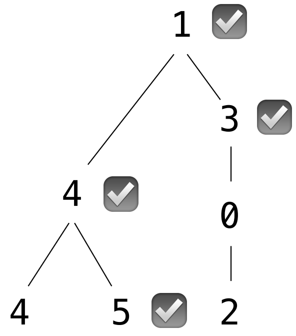

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    4
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Somehow track the largest ancestor

A node in t

max_ancestor

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Somehow increment the total count

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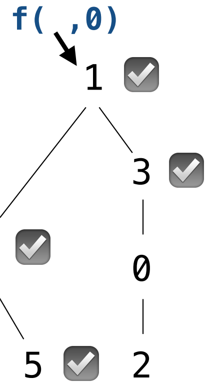

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```

Somehow track the largest ancestor

A node in t → a

max_ancestor → x

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

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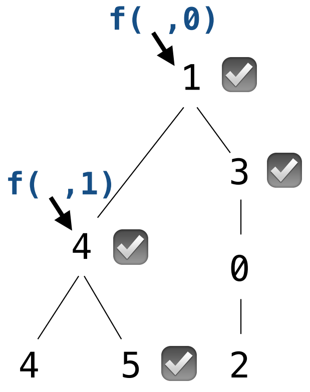

Solving Tree Problems

```
Implement bigs, which takes a Tree instance t containing integer labels. It returns the
number of nodes in t whose labels are larger than any labels of their ancestor nodes.
```

```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors.

    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x:
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        else:
            return sum([f(b, x) for b in a.branches])
    return f(t, t.label - 1)
```

A node in t

max_ancestor

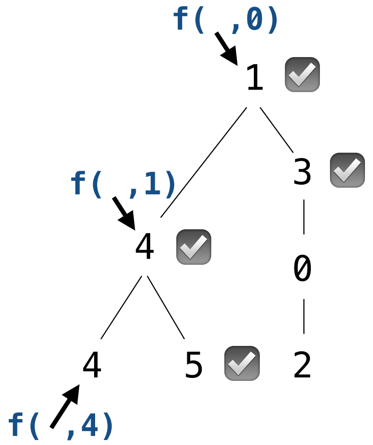
Somehow track the largest ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

Some initial value for the largest ancestor so far...



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    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x                                              :

            return 1 + sum([f(b, a.label) for b in a.branches])

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            return     sum([f(b, x) for b in a.branches])

    return f(t, t.label - 1)
```

Somehow track the largest ancestor

A node in t

max_ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

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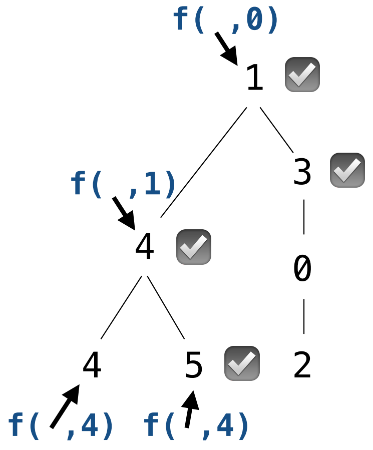

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    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x:
            return 1 + sum([f(b, a.label) for b in a.branches])
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            return sum([f(b, x) for b in a.branches])
    return f(t, t.label - 1)
```

Somehow track the largest ancestor

A node in t

max_ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

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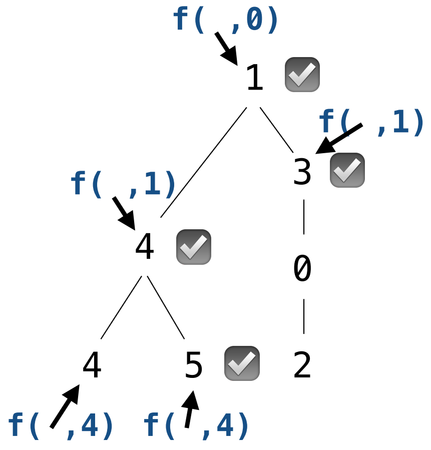

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

```python
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors.

    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if  a.label > x  :
            return 1 + sum([f(b, a.label) for b in a.branches])
        else:
            return     sum([f(b, x) for b in a.branches])
    return  f(t, t.label - 1)
```

A node in t

max_ancestor

Somehow track the largest ancestor

node.label > max_ancestors

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Root label is always larger than its ancestors

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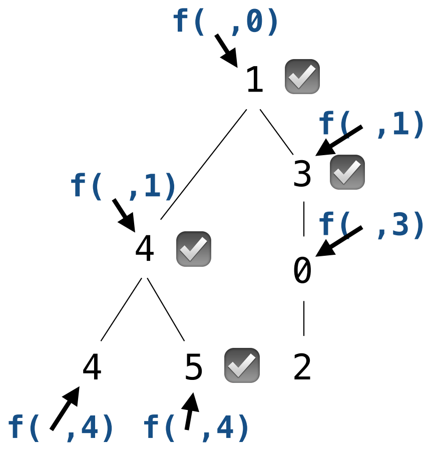

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    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x                                        :
            return 1 + sum([f(b, a.label) for b in a.branches])
        else:
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    return f(t, t.label - 1)
```

Somehow track the largest ancestor

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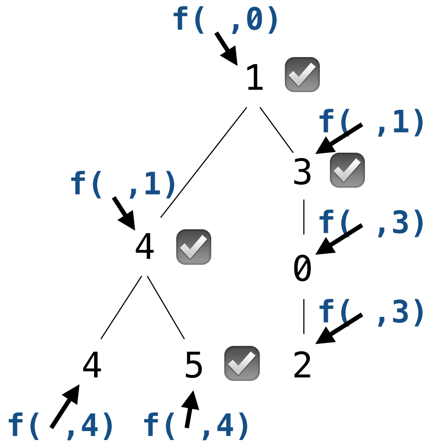

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    >>> a = Tree(1, [Tree(4, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(2)])])])
    >>> bigs(a)
    4
    """
    def f(a, x):
        if a.label > x :
            return 1 + sum( f(b, a.label) for b in a.branches )
        else:
            return sum( f(b, x) for b in a.branches )
    return f(t, t.label - 1)
```

Somehow track the largest ancestor

A node in t

max_ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

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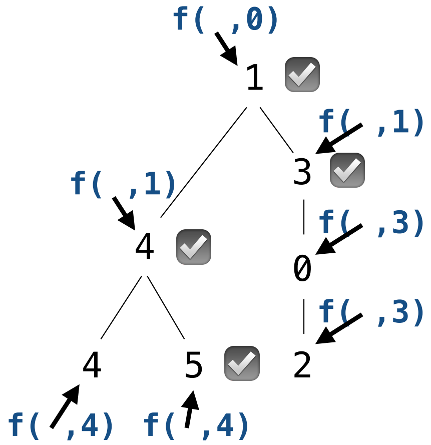

Recursive Accumulation

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors."""
    n = 0

    def f(a, x):

        ___________________________

        if ________________________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors."""
    n = 0

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        ___________________________

        if ________________________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

Somehow track the largest ancestor

Solving Tree Problems

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        ___________________________

        if ________________________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

Somehow track the largest ancestor

node.label > max_ancestors

Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

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def bigs(t):
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    n = 0

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        ___________________________

        if ________________________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

Somehow track the largest ancestor

node.label > max_ancestors

Somehow increment the total count

Solving Tree Problems

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        ___________________________

        if ________________________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

Somehow track the largest ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

Solving Tree Problems

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```
def bigs(t):
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    n = 0

    def f(a, x):

        ___________________________

        if a.label > x_____________:

            n += 1

        ___________________________:

            f(_____________________)

    _______________________________

    return n
```

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        ___________________________

        if a.label > x_____________:

            n += 1

        ___________________________:

            f(_____________________)

    f(t, t.label - 1)
    ______________________________

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```

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    n = 0

    def f(a, x):

        ___________________________

        if a.label > x_____________:

            n += 1

        for b in a.branches________:

            f(_____________________)

    f(t, t.label - 1)
    ___________________________

    return n
```

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    n = 0

    def f(a, x):

        ____________________________

        if a.label > x             :

            n += 1

        for b in a.branches        :

            f( b, max(a.label, x) )

    f(t, t.label - 1)

    return n
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Solving Tree Problems

Implement **bigs**, which takes a Tree instance t containing integer labels. It returns the number of nodes in t whose labels are larger than any labels of their ancestor nodes.

```
def bigs(t):
    """Return the number of nodes in t that are larger than all their ancestors."""
    n = 0

    def f(a, x):

        nonlocal n

        if a.label > x:

            n += 1

        for b in a.branches:

            f(b, max(a.label, x))

    f(t, t.label - 1)

    return n
```

Somehow track the largest ancestor

node.label > max_ancestors

Somehow increment the total count

Root label is always larger than its ancestors

Designing Functions

How to Design Programs

https://htdp.org/2018-01-06/Book/

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From Problem Analysis to Data Definitions
Identify the information that must be represented and how it is represented in the chosen programming language. Formulate data definitions and illustrate them with examples.

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Functional Examples
Work through examples that illustrate the function’s purpose.

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Function Template
Translate the data definitions into an outline of the function.

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Articulate the examples as tests and ensure that the function passes all. Doing so discovers mistakes. Tests also supplement examples in that they help others read and understand the definition when the need arises—and it will arise for any serious program.

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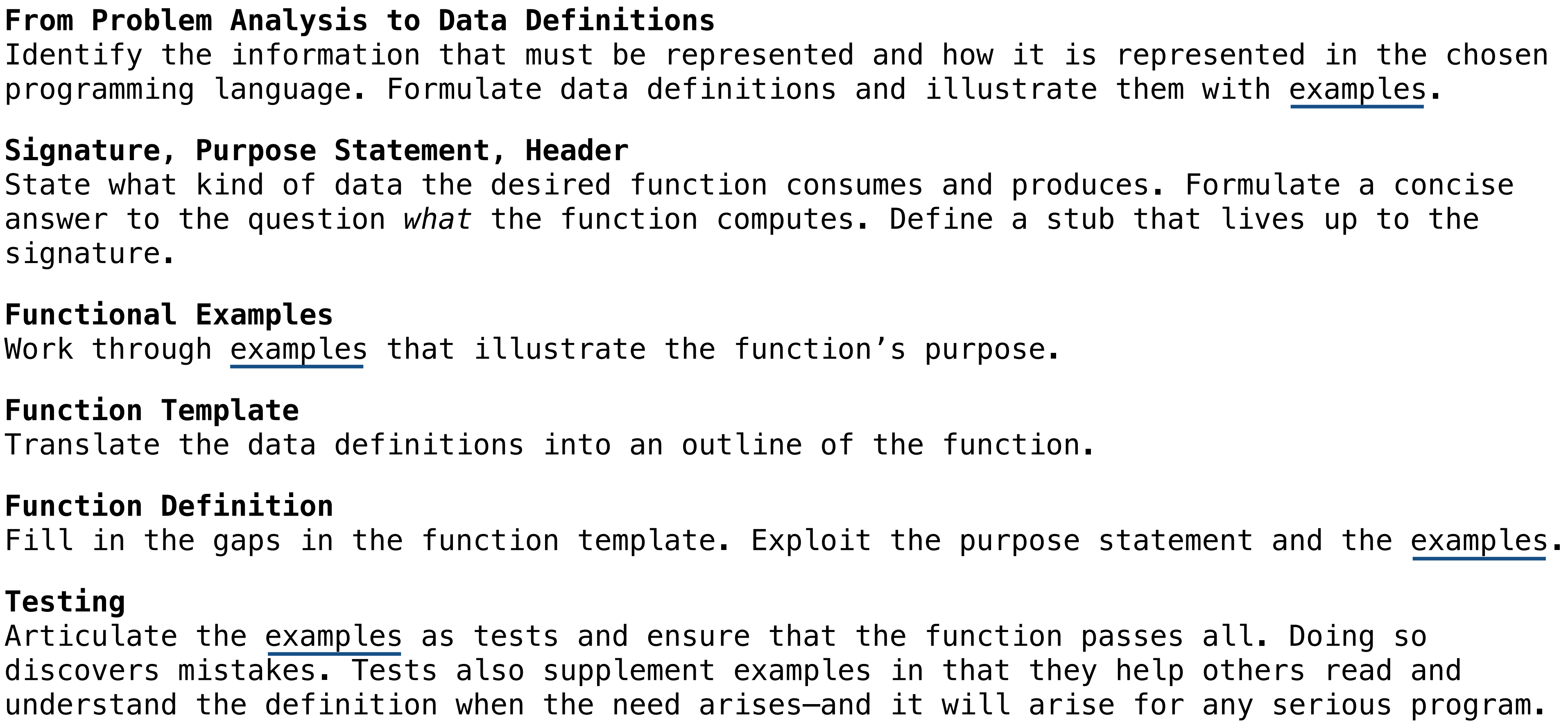

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Applying the Design Process

Designing a Function

Implement **smalls**, which takes a Tree instance t containing integer labels. It returns the non-leaf nodes in t whose labels are smaller than any labels of their descendant nodes.

```
def smalls(t):
    """Return the non-leaf nodes in t that are smaller than all their descendants.

    >>> a = Tree(1, [Tree(2, [Tree(4), Tree(5)]), Tree(3, [Tree(0, [Tree(6)])])])
    >>> sorted([t.label for t in smalls(a)])
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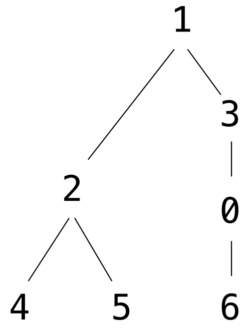

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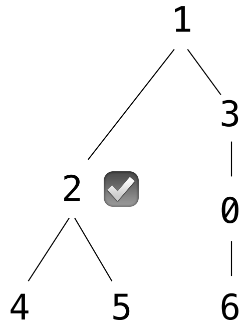

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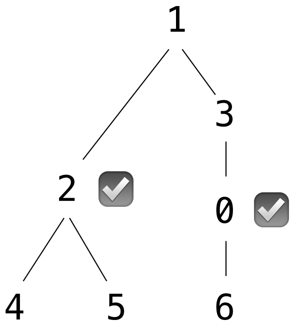

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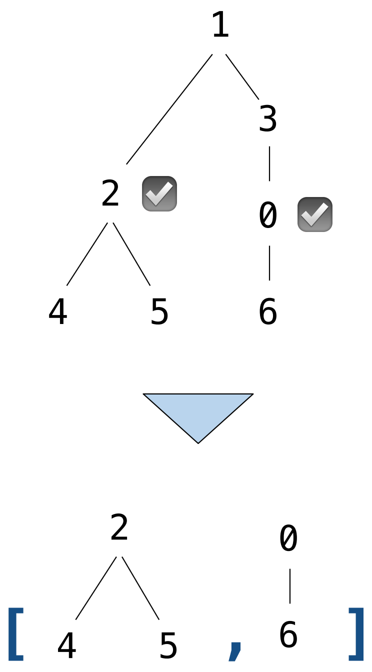

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Signature: Tree -> number

```
    result = []
    def process(t):




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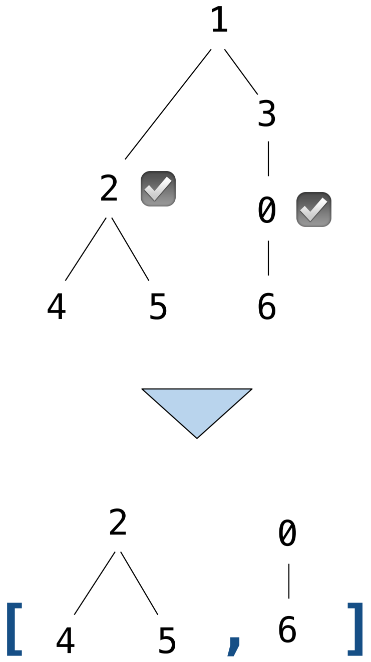

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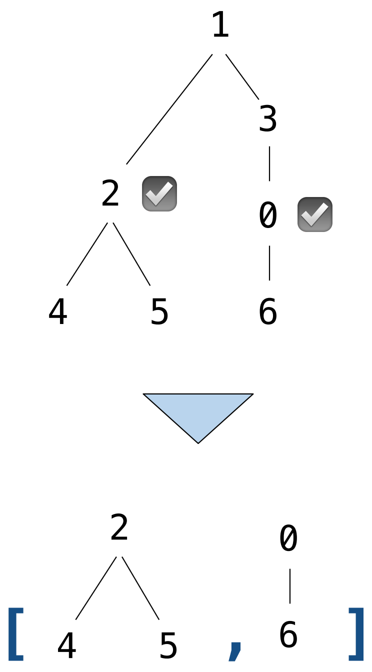
"Find smallest label in t & maybe add t to result"



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    """
```

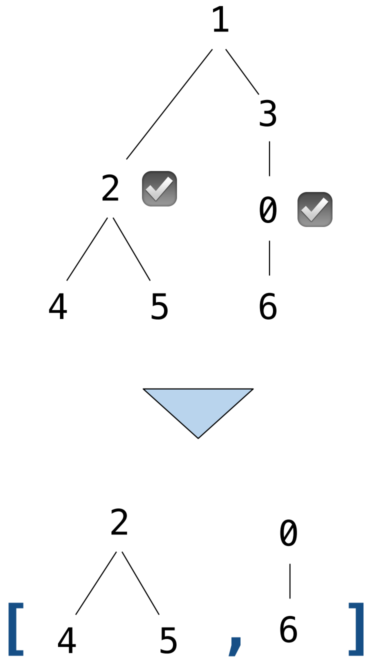
Signature: Tree -> number

"Find smallest label in t & maybe add t to result"

```
    result = []
    def process(t):
        if t.is_leaf():
            return t.label
        else:



            return min(...)
    process(t)
    return result
```



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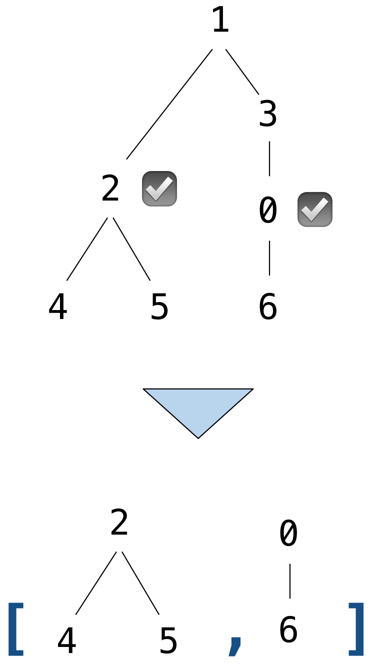
    """
    result = []
    def process(t):
        if t.is_leaf():
            return ___________________________________________
        else:
            smallest = _______________________________________
            if ______________________________________________:
                _____________________________________________
            return min(smallest, t.label)
    process(t)
    return result
```

Signature: Tree -> number

"Find smallest label in t & maybe add t to result"



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            if ________________________________________:
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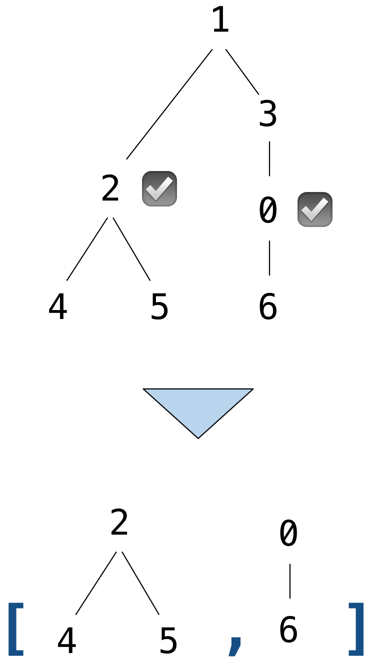

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```
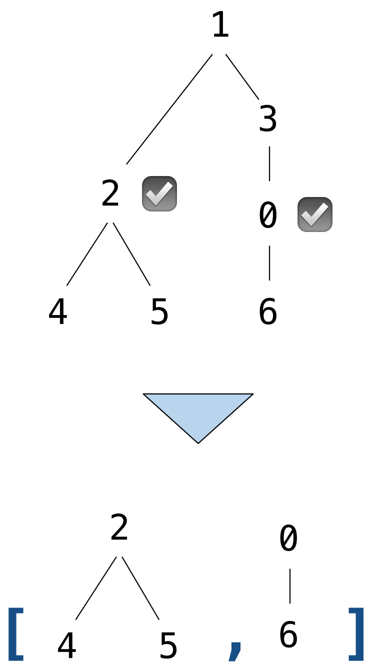

Signature: Tree -> number

"Find smallest label in t & maybe add t to result"

smallest label in a branch of t



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    result = []
    def process(t):
        if t.is_leaf():
            return _______________t.label_______________
        else:
            smallest = ______________________________
            if ____t.label < smallest____________________:
                __________________________________________
            return min(smallest, t.label)
    process(t)
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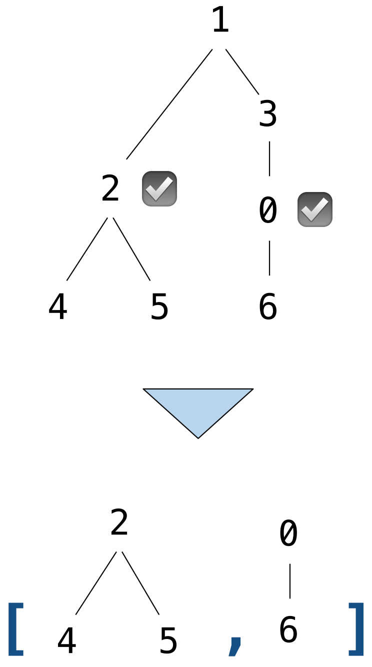
```

Signature: Tree -> number

"Find smallest label in t & maybe add t to result"

smallest label in a branch of t



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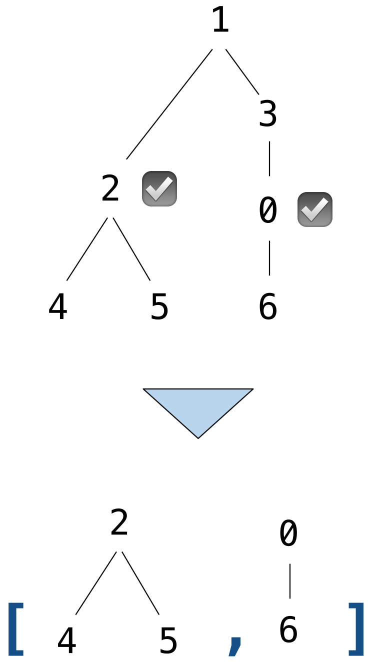

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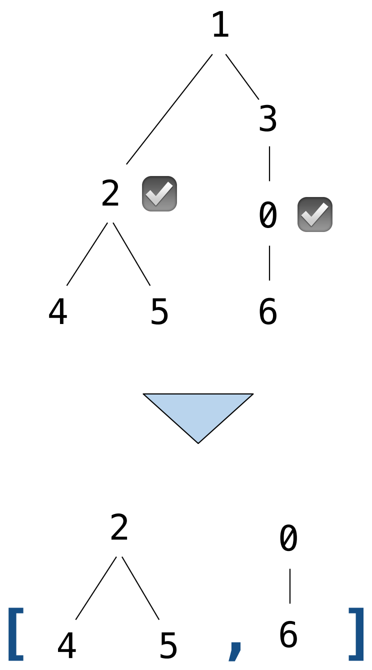

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    """
    result = []
    def process(t):
        if t.is_leaf():
            return t.label
        else:
            smallest = min([process(b) for b in t.branches])
            if t.label < smallest:
                result.append( t )
            return min(smallest, t.label)
    process(t)
    return result
```

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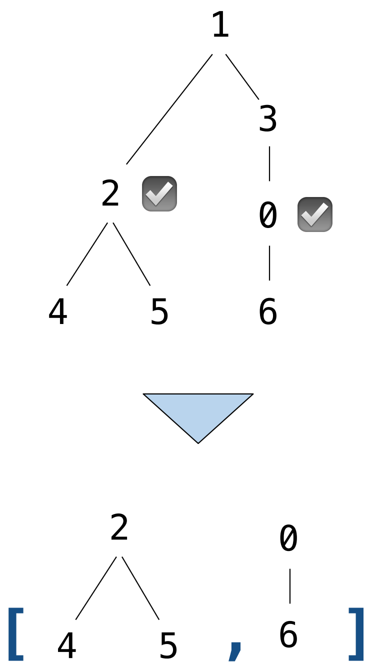
smallest label in a branch of t



Society

Privacy Policies and Laws

Privacy Policies and Laws

Mark Zuckerberg in San Francisco, January 8, 2010

> "People have really gotten comfortable not only sharing more information and different kinds, but more openly and with more people. That social norm is just something that has evolved over time."

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- Third, the **right to access.** Companies should recognize that data belongs to users, and we should all make it easy for users to get a copy of, correct, and delete their personal data.

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- Third, the **right to access.** Companies should recognize that data belongs to users, and we should all make it easy for users to get a copy of, correct, and delete their personal data.
- And fourth, the **right to security.** Security is foundational to trust and all other privacy rights."

Perils of Sharing

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A persistent source of privacy breaches: sending a message to an unintended recipient

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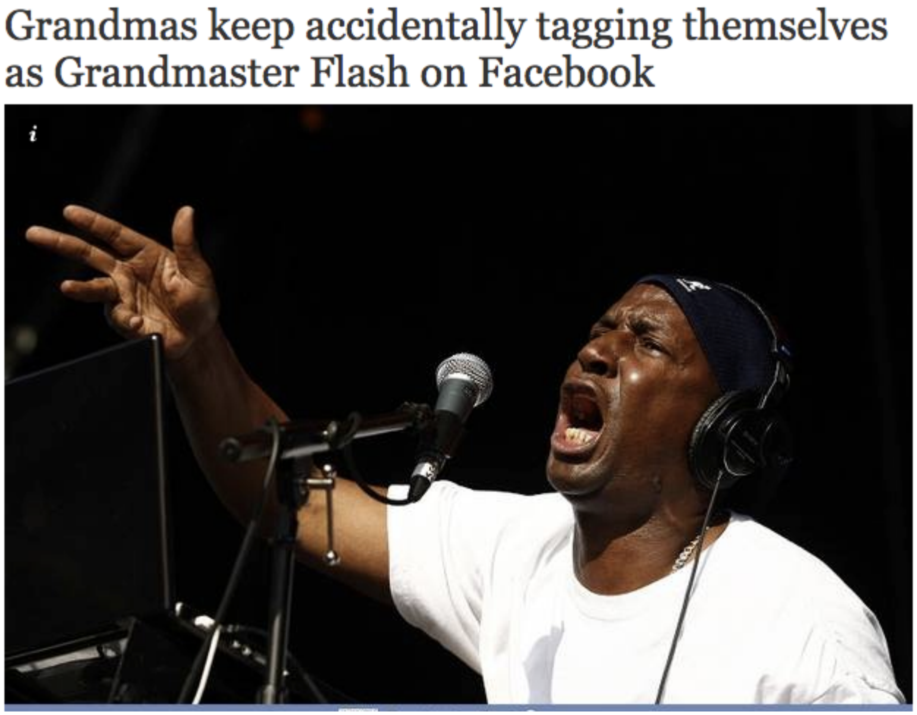
A persistent source of privacy breaches: sending a message to an unintended recipient



Grandmas keep accidentally tagging themselves as Grandmaster Flash on Facebook

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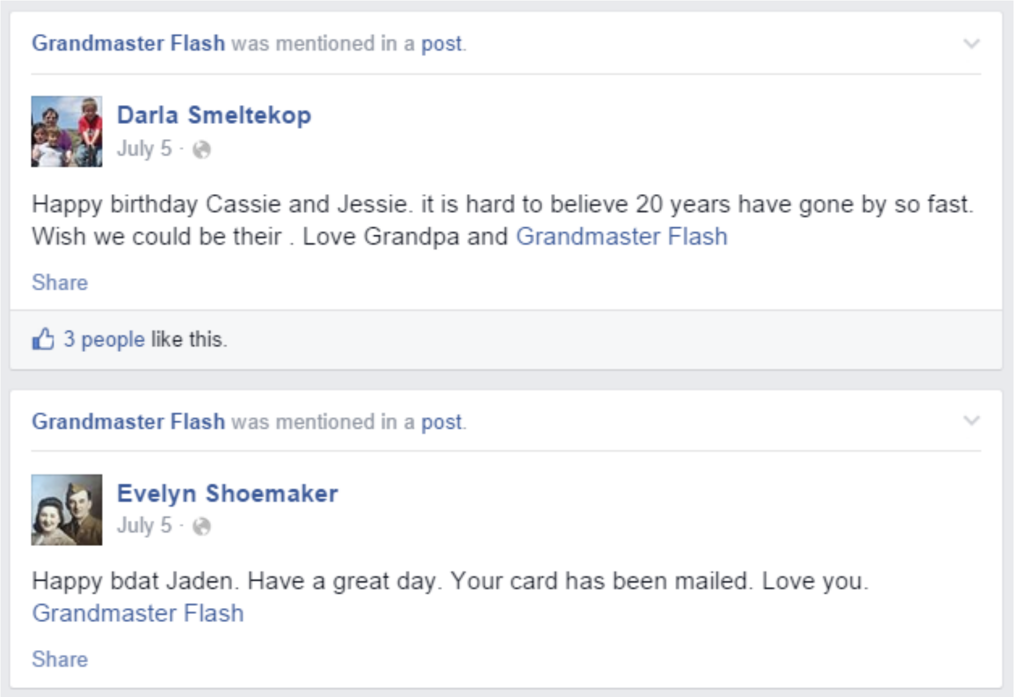


Grandmaster Flash was mentioned in a **post**.

Darla Smeltekop
July 5 ·

Happy birthday Cassie and Jessie. it is hard to believe 20 years have gone by so fast. Wish we could be their . Love Grandpa and Grandmaster Flash

Grandmaster Flash was mentioned in a **post**.

Evelyn Shoemaker
July 5 ·

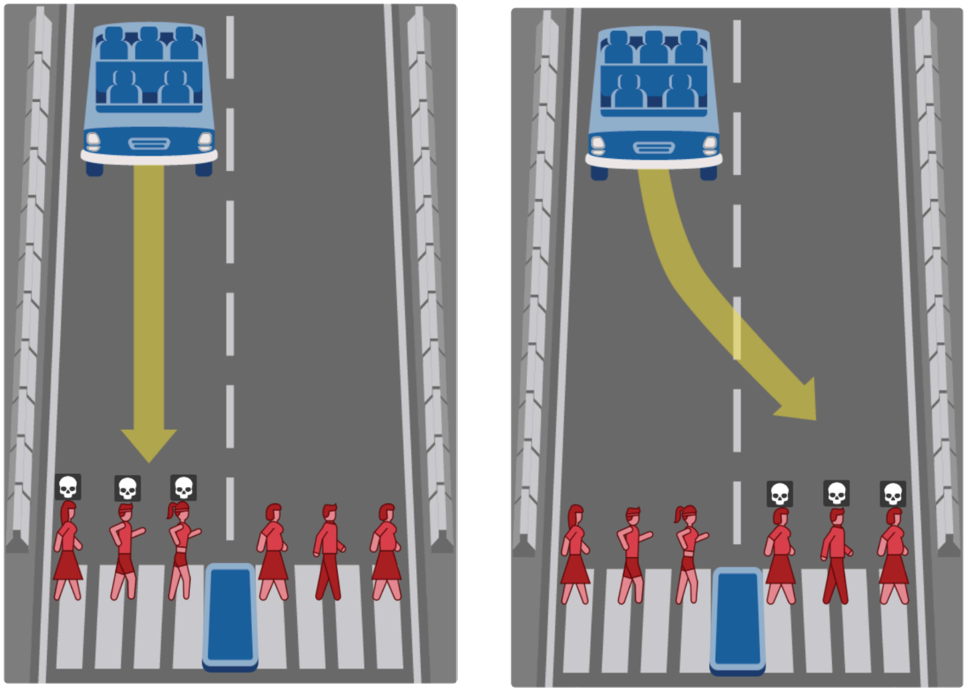
Happy bdat Jaden. Have a great day. Your card has been mailed. Love you. Grandmaster Flash

Software

Automated Decision Making

Automated Decision Making

What should the self-driving car do?



Automated Decision Making

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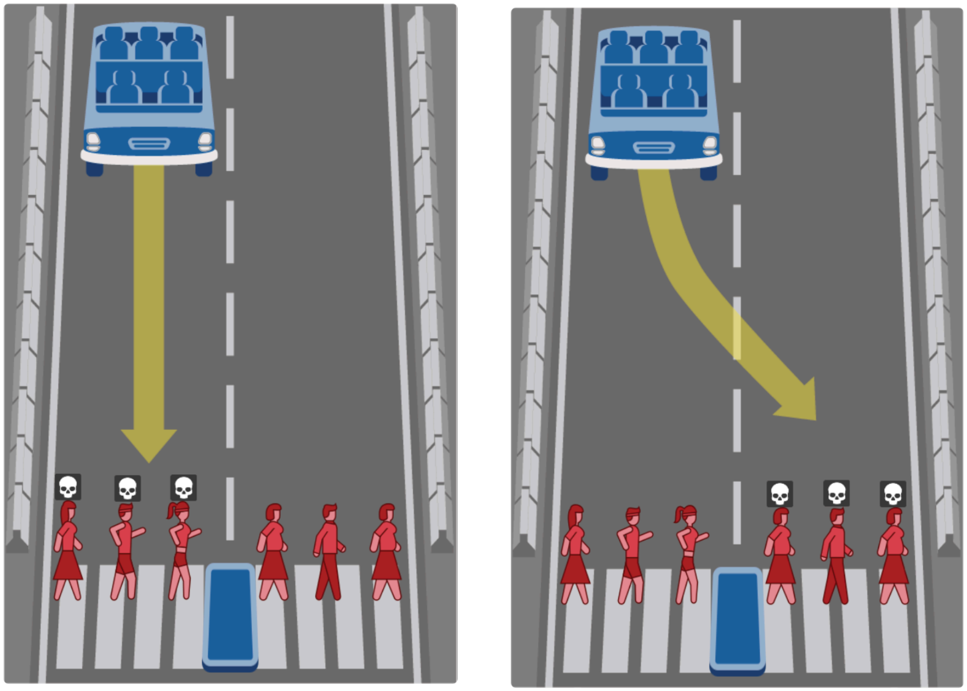
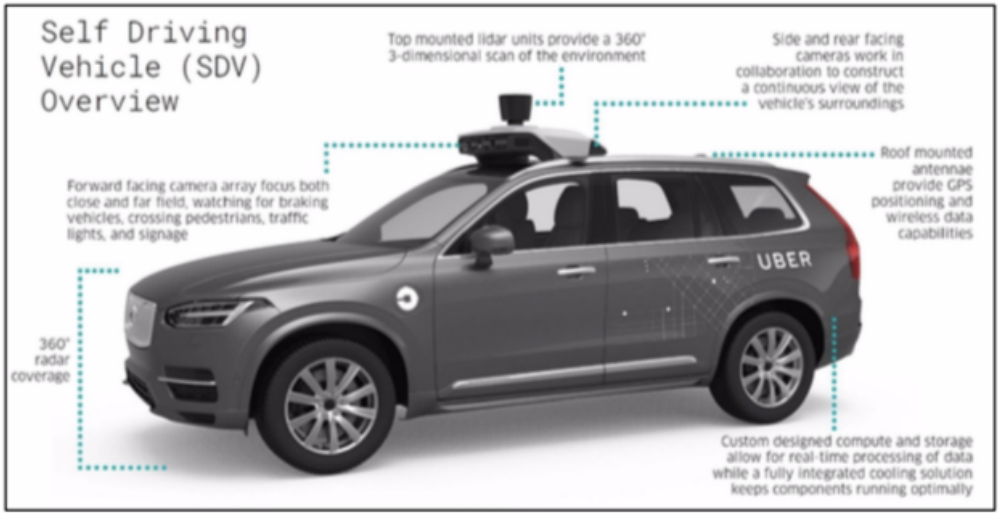




Self Driving Vehicle (SDV) Overview

Top mounted lidar units provide a 360° 3-dimensional scan of the environment

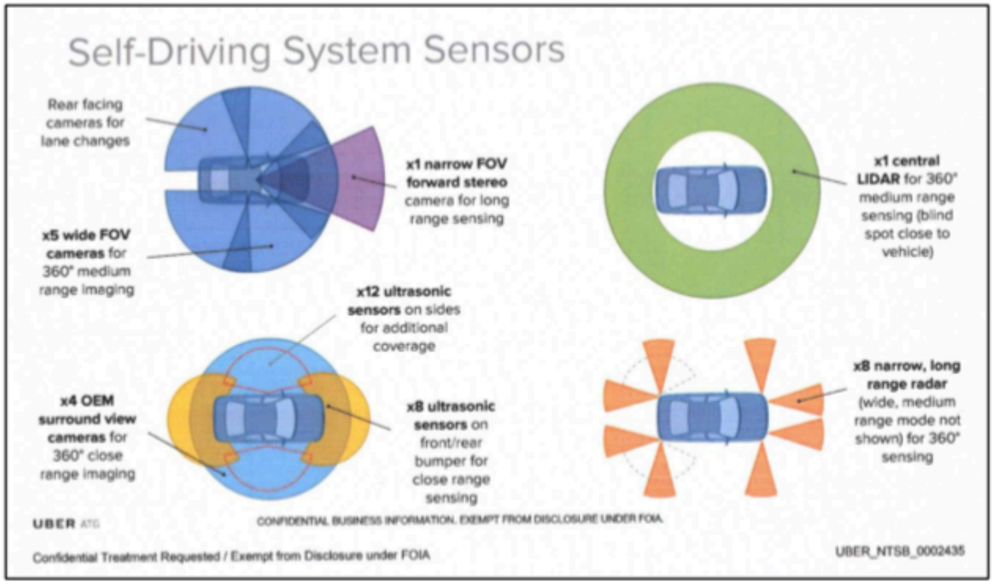
Side and rear facing cameras work in collaboration to construct a continuous view of the vehicle's surroundings

Forward facing camera array focus both close and far field, watching for braking vehicles, crossing pedestrians, traffic lights, and signage

Roof mounted antennae provide GPS positioning and wireless data capabilities

360° radar coverage

Custom designed compute and storage allow for real-time processing of data while a fully integrated cooling solution keeps components running optimally



Self-Driving System Sensors

Rear facing cameras for lane changes

x1 narrow FOV forward stereo camera for long range sensing

x5 wide FOV cameras for 360° medium range imaging

x1 central LIDAR for 360° medium range sensing (blind spot close to vehicle)

x12 ultrasonic sensors on sides for additional coverage

x4 OEM surround view cameras for 360° close range imaging

x8 ultrasonic sensors on front/rear bumper for close range sensing

x8 narrow, long range radar (wide, medium range mode not shown) for 360° sensing

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Life