Recursive Functions

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Recursive Functions

- A recursive function calls itself in a calling sequence.
- For example

```
void f( … ) {
   …
   f( … )
   …

 }
```

```
void g( … ) {
   …
   f( … )
   …

}
void f( … ) {
   …
   g( … )
   …

 }
```

Recursive Functions

- A recursive function solves a problem by solving the associated sub-problems and combining the solutions of the sub-problems.

```
void f( … ) {
  …
  f( … )
  …

}
```

```
void g( … ) {
  …
  f( … )
  …

}
void f( … ) {
  …
  g( … )
  …

}
```

Recursive Functions

What is the purpose of the code fragment?

```
int s = 1;
if ( n == 0 ) return s;
s = n*f(n-1);
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Recursive Functions

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```
int u( int n ) {
    int s = 1;
    if ( n == 0 ) return s;
    s = n*f(n-1);
    return s;
}
```

If n is zero, return s.
Otherwise, set s as n*f(n-1).
Then return s.

Recursive Functions

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int f( int n ) {
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If n is zero, return s.
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???

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Need to give the high level idea about the function f.

Recursive Functions

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Need to give the high level idea about the function f.

f( ) performs the same action every time.
But n is reduced by 1 every time.

Recursive Functions

```
int f( int n ) {
    int s = 1;
    if ( n == 0 ) return s;
    s = n*f(n-1);
    return s;
}
```

n = 7

```
f(7) {
  …
  s = 7*f(6);
  …
}
```

If n is zero, return s.
Otherwise, set s as n*f(n-1).
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Dry-run: tracing the function call(s)

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```

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```
f(7) {
  …
  s = 7*f(6);
  …
}
```

n = 6

```
f(6) {
  …
  s = 6*f(5);
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If n is zero, return s.
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f(6) {
  …
  s = 6*f(5);
  …
}
```

n = 5

```
f(5) {
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  s = 5*f(4);
  …
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```

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f(7) { … s = 7*f(6); … }	f(6) { … s = 6*f(5); … }	f(5) { … s = 5*f(4); … }	……

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When should be

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  …
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}
```

n = 6

```
f(6) {
  …
  s = 6*f(5);
  …
}
```

n = 5

```
f(5) {
  …
  s = 5*f(4);
  …
}
```

……

```
f(n=?) {
  …

  …
}
```

Dry-run: tracing the function call(s)

For the case(s), f( ) does not call itself. (directly or indirectly).

Recursive Functions

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Combining the results of sub-problems

For the case(s), f( ) does not call itself. (directly or indirectly).

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n = 5

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  …
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  …
}
```

……

```
f(0) {
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s=7*f(6)

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s=7*6*5*f(4)……*1

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To understand a recursive function
(It does one job.)

① Dry-run: tracing the function call(s)
② Combining the results of sub-problems
③ Generalize the results

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  …
}
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……

```
f(0) {
  …
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s=7*6*5*4*3*……*1

For the case(s), f( ) does not call itself. (directly or indirectly).

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s=7*6*5*4*3*2*……*1

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s=7*6*5*4*3*2*1*……*1

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}
```

n = 5

```
f(5) {
  …
  s = 5*f(4);
  …
}
```

……

```
f(0) {
  …
  return 1;
  …
}
```

s=7*6*5*4*3*2*1 = 7!

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When should be terminated?

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n	n-1	n -2		0
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n

```
f(n) {
  …
  s = n
     *f(n-1);
  …
}
```

n-1

```
f(6) {
  …
  s = (n-1)
     *f(n-2);
  …
}
```

n -2

```
f(5) {
  …
  s = (n-2)
     *f(n-3);
  …
}
```

……

0

```
f(0) {
  …
  return 1;
  …
}
```

s=n*(n-1)*(n-2)*……*1

For the case(s), f( ) does not call itself. (directly or indirectly).

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n	n-1	n -2		0
f(n) { … s = n *f(n-1); … }	f(6) { … s = (n-1) *f(n-2); … }	f(5) { … s = (n-2) *f(n-3); … }	……	f(0) { … return 1; … }

s=n*(n-1)*(n-2)*……*1*1 = n!

For the case(s), f( ) does not call itself. (directly or indirectly).

Recursive Functions

```
int f( int n ) {
    int s = 1;
    if ( n == 0 ) return s;
    s = n*f(n-1);
    return s;
}
```

If n is zero, return s.
Otherwise, set s as n*f(n-1).
Then return s.

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Recursive Functions

To understand a recursive function
(It does one job.)

① Dry-run: tracing the function call(s)
② Combining the results of sub-problems
③ Generalize the results

```
int f( int n ) {
    int s = 1;
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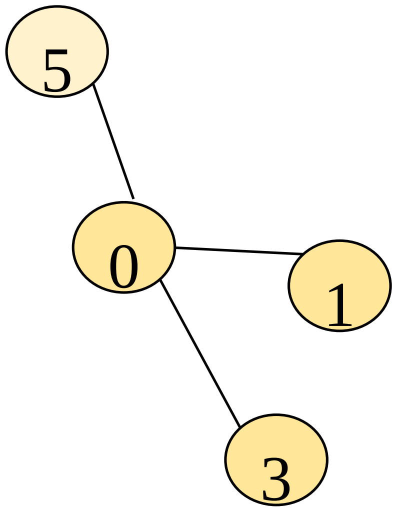
    return s;
}
```

Depth-First Search

Traverse a graph or a tree in a depth-first manner. That's that, a node is explored if it has not been visited.

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dfs(vertex v)
  visit v;
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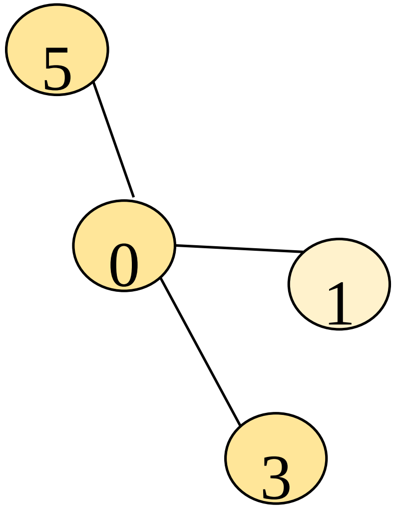

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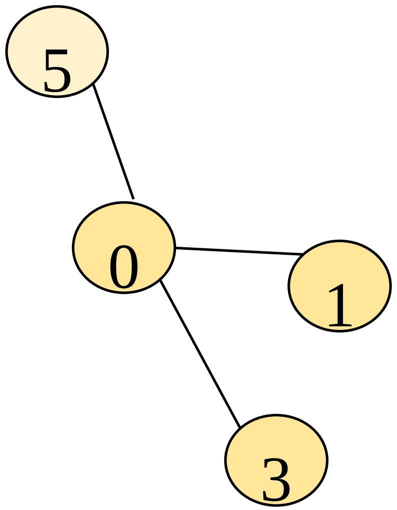
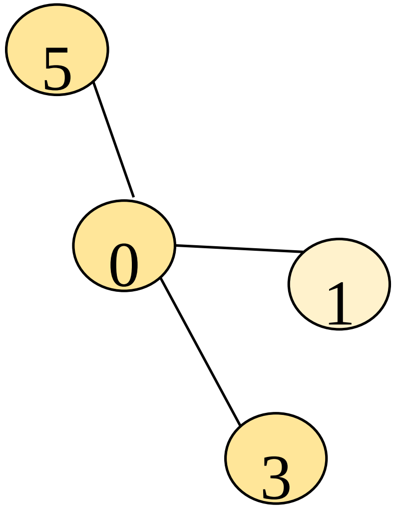



```
Invoke dfs(Node 0). Possible result(s):
```



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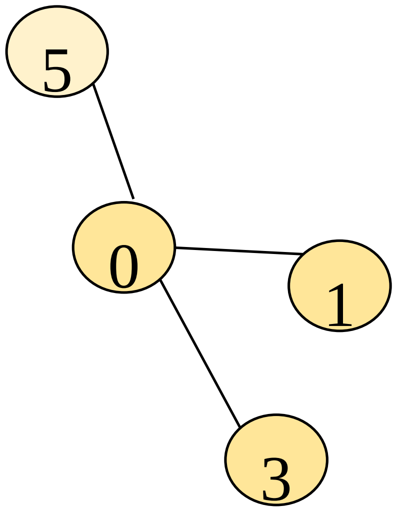


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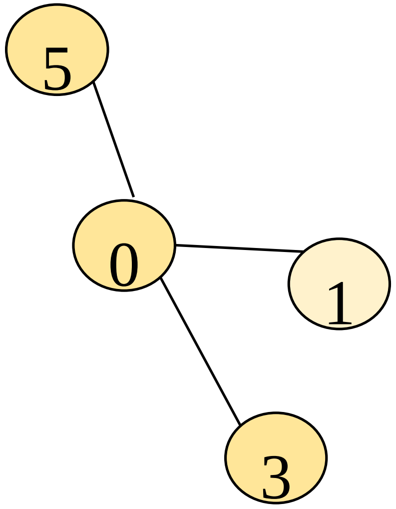


```
Invoke dfs(Node 0). Possible result(s):
3,0,1,5
3,0,5,1
```

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Traverse a graph or a tree in a depth-first manner. That's that, a node is explored if it has not been visited.

```
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  visit v;
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      foo(w);
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Depth-First Search

Given a node v = v_0

```
visit v;
for each neighbor w of v
  if (w is not visited)
    foo(w);
```

Depth-First Search

Given a node $v = v_0$

What do you do?

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Depth-First Search

Given a node $v = v_1$

```
visit v;
for each neighbor w of v
  if (w is not visited)
    foo(w);
```

1. What do you do?
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Depth-First Search

Given a node v = v_2

```
visit v;
for each neighbor w of v
  if (w is not visited)
    foo(w);
```

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Depth-First Search

Given a node $v = v_j$

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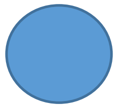

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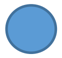

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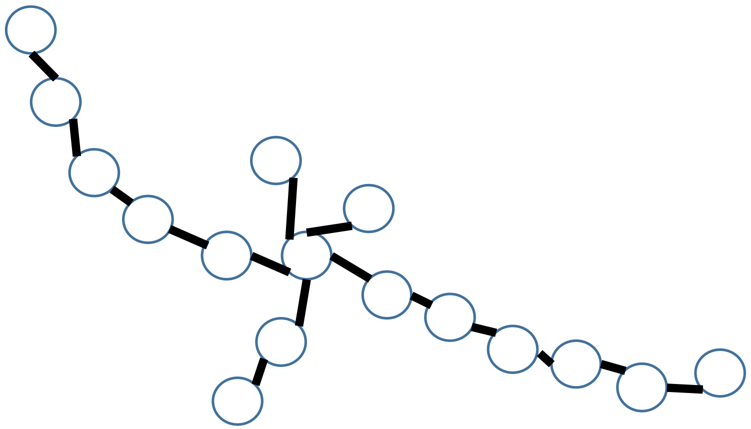

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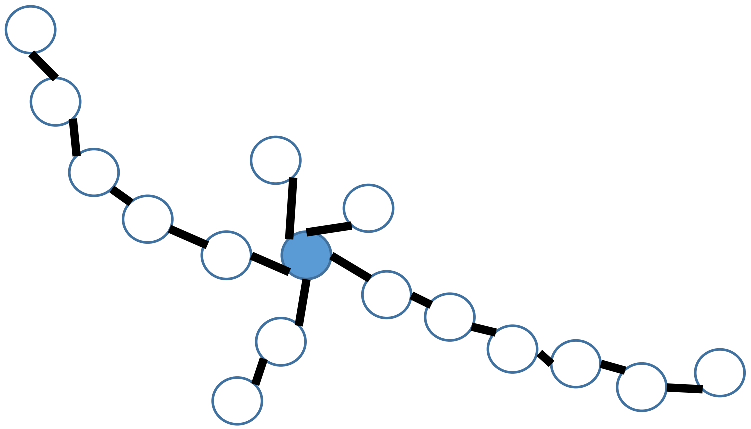

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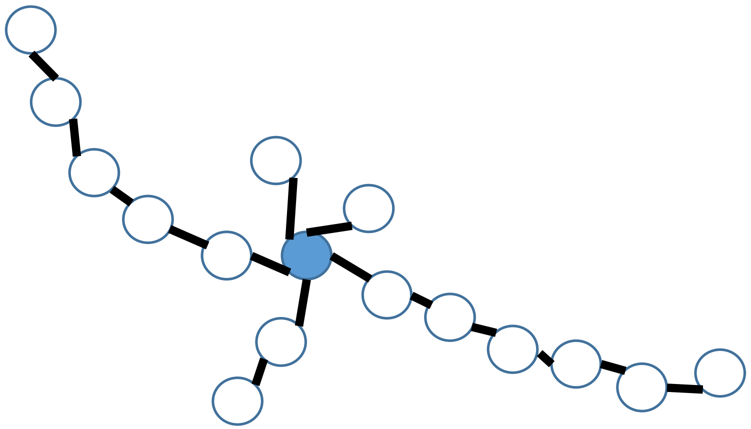

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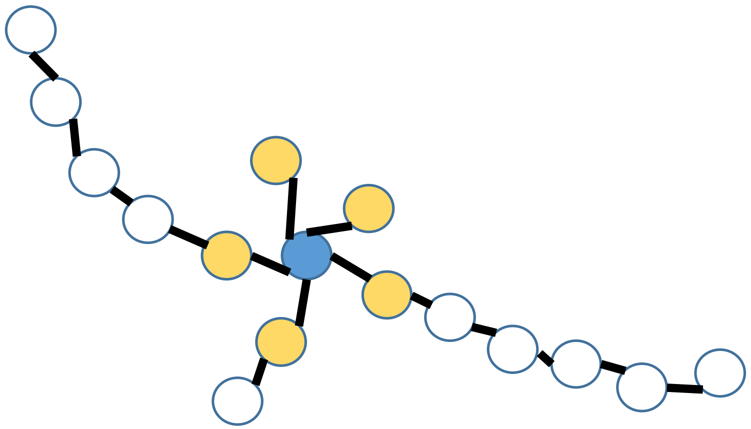

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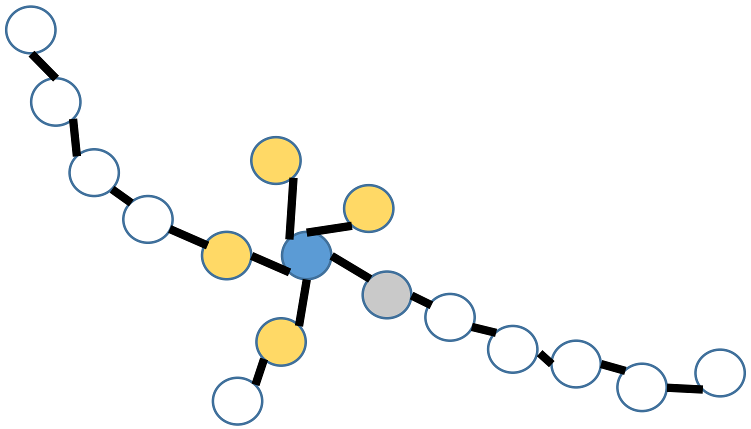

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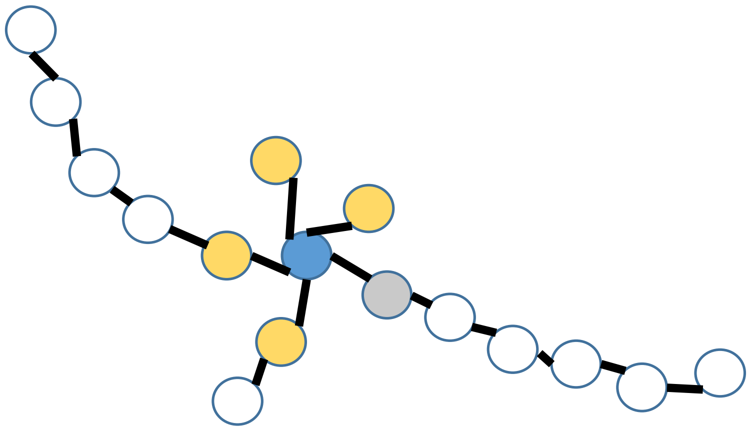

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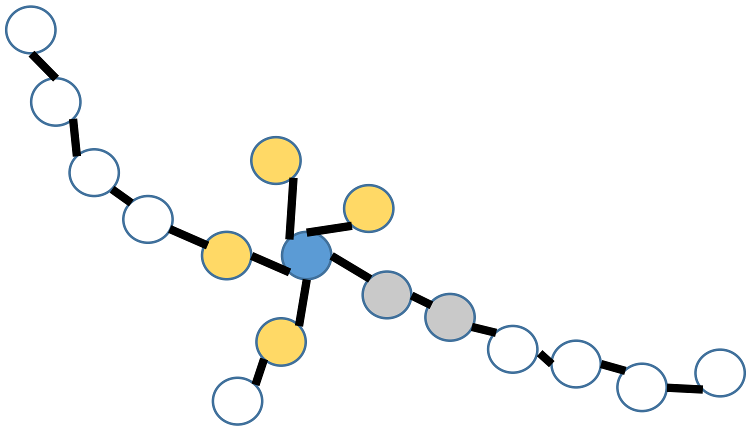

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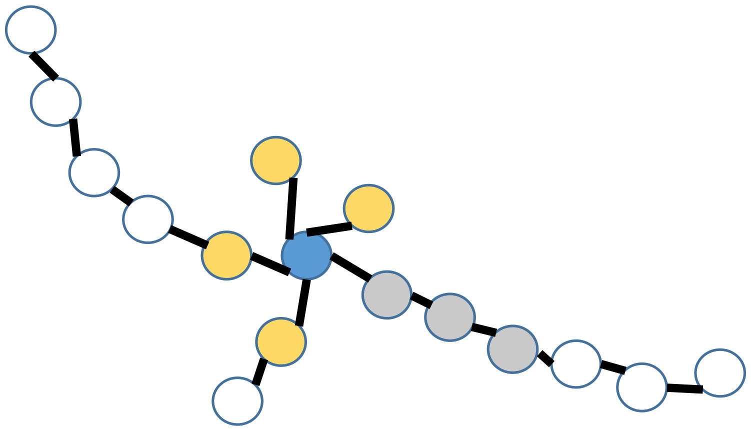

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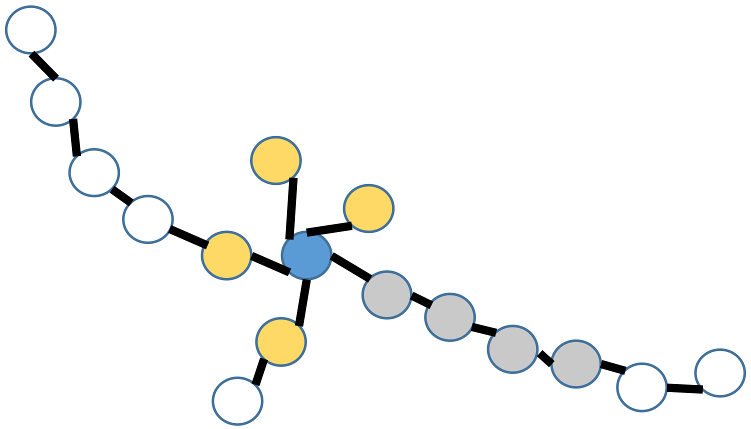

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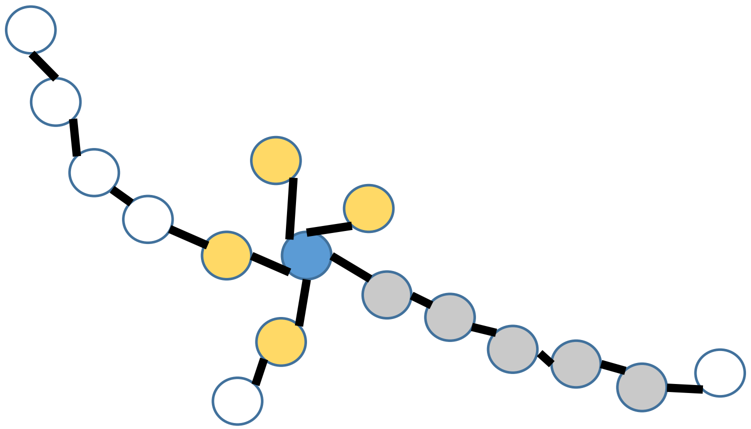

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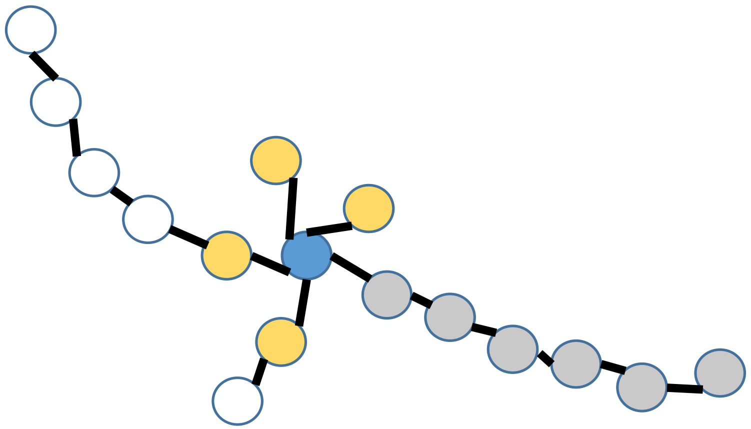

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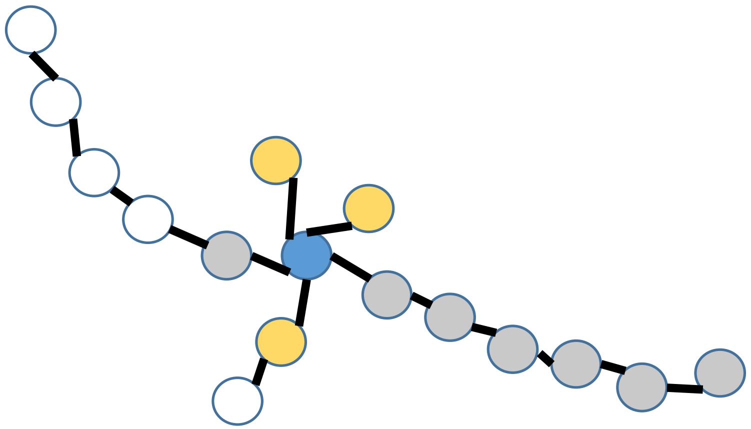

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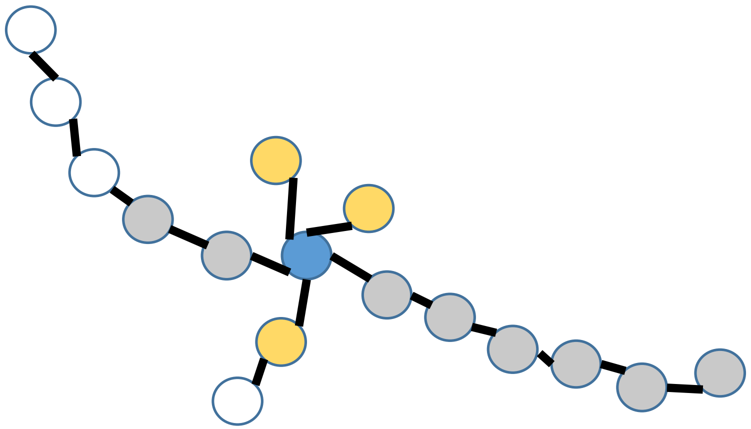

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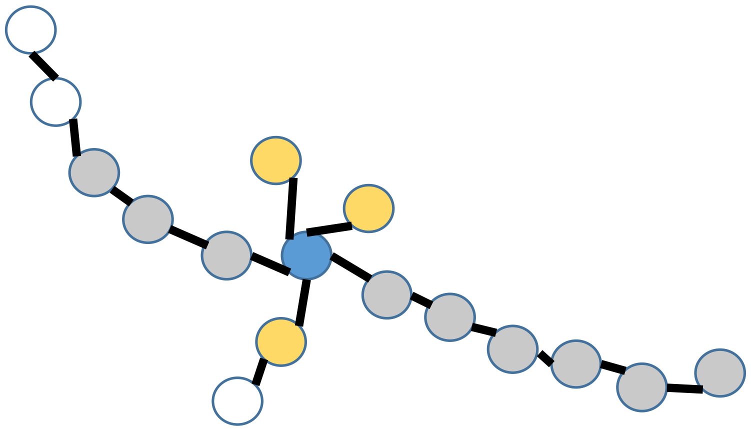

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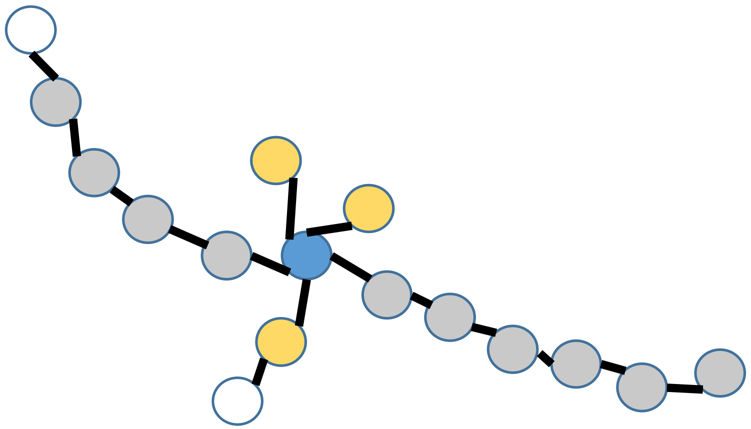

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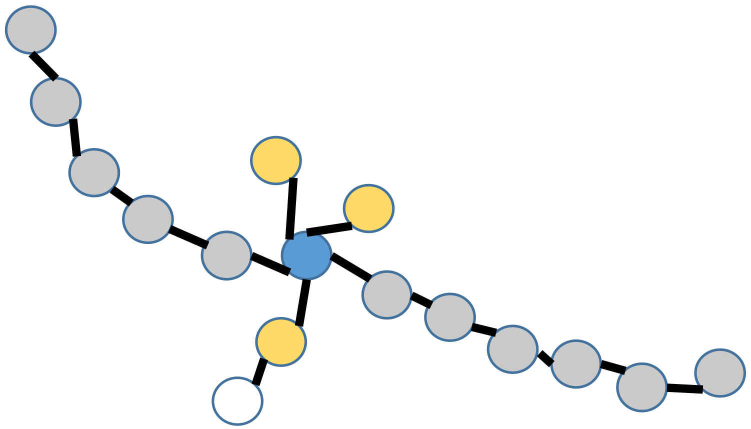

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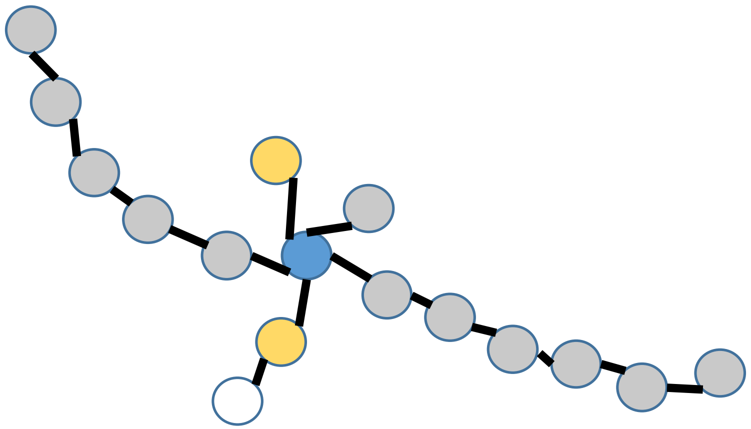

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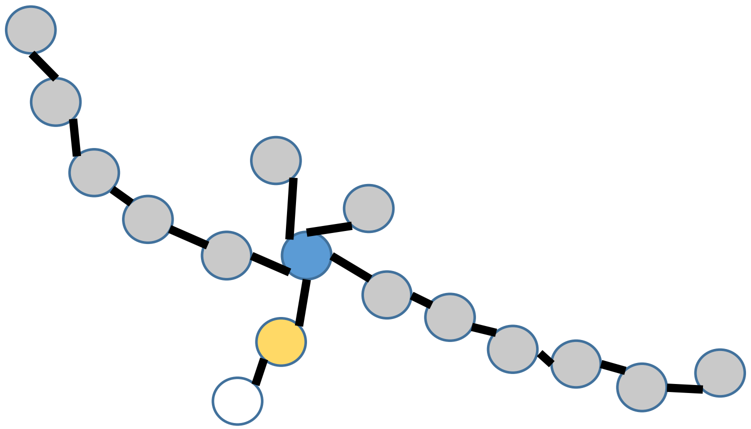

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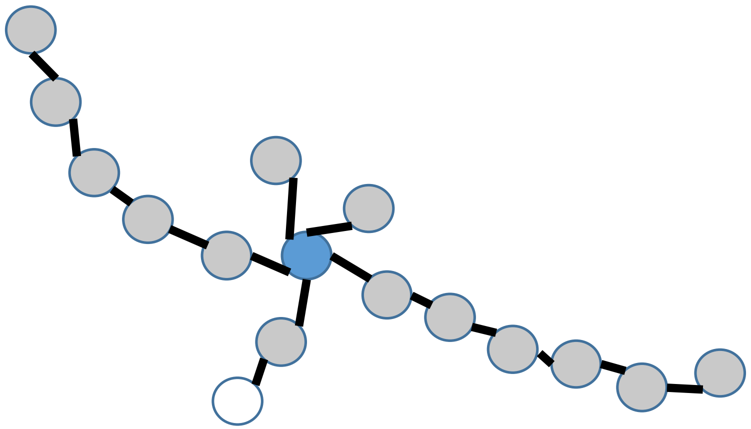

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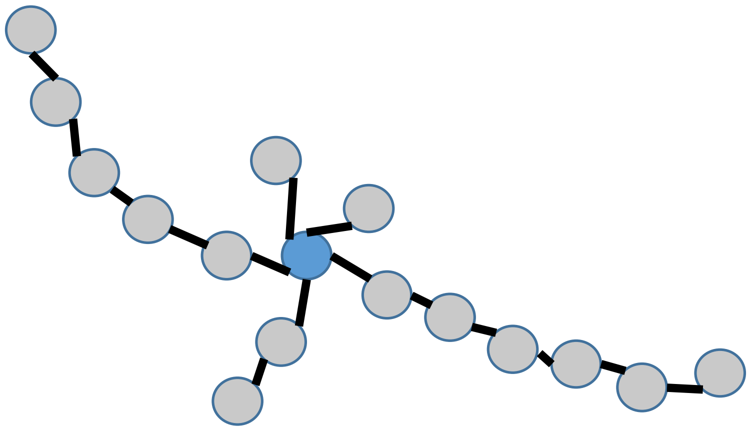

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Now, you should generalize your findings.

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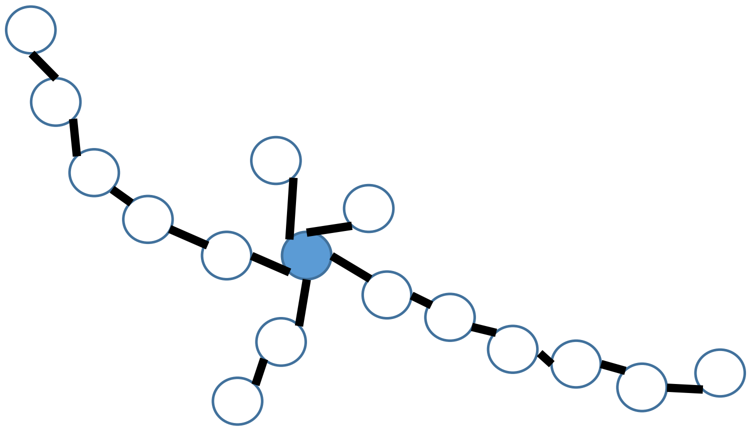

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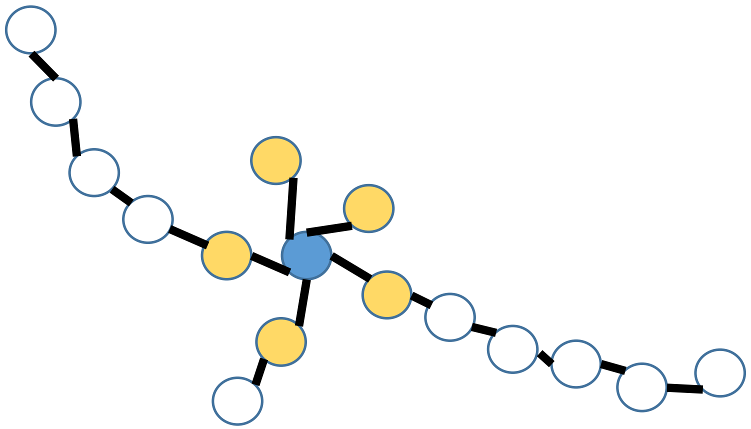

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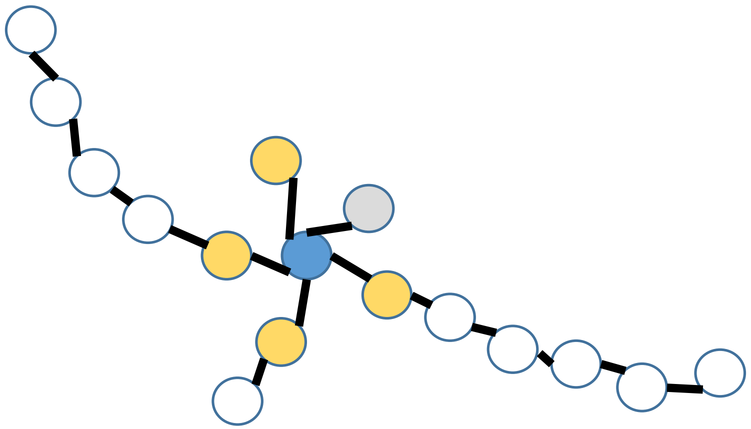

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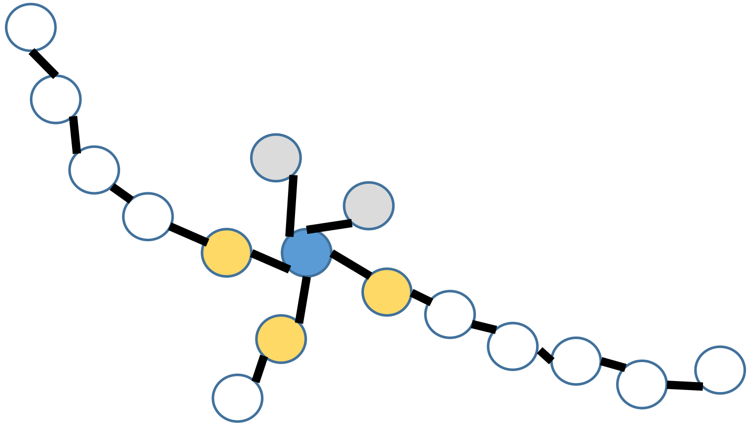

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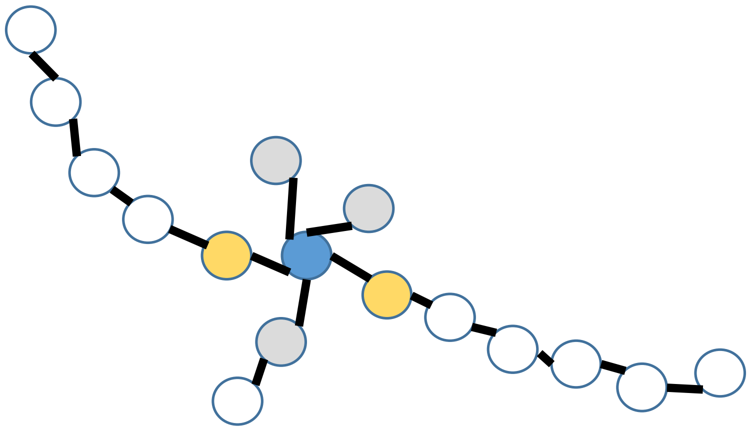

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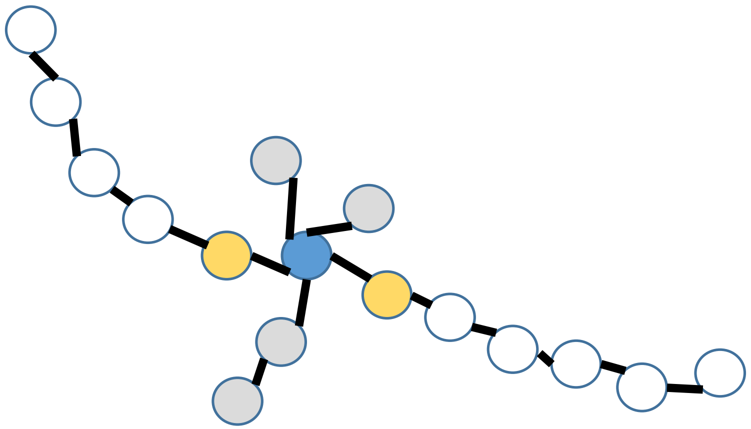

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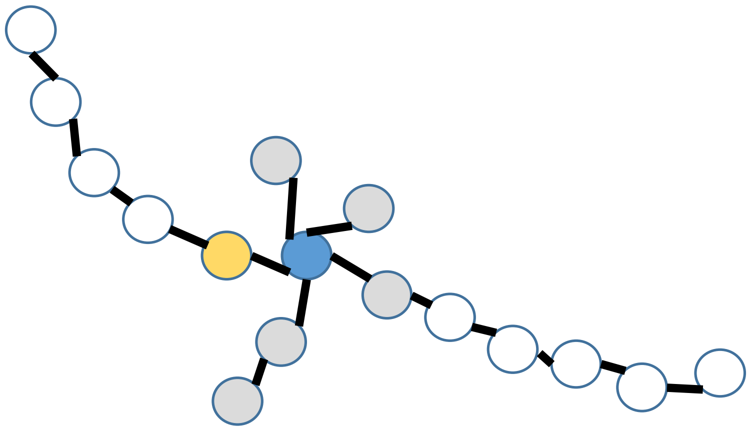

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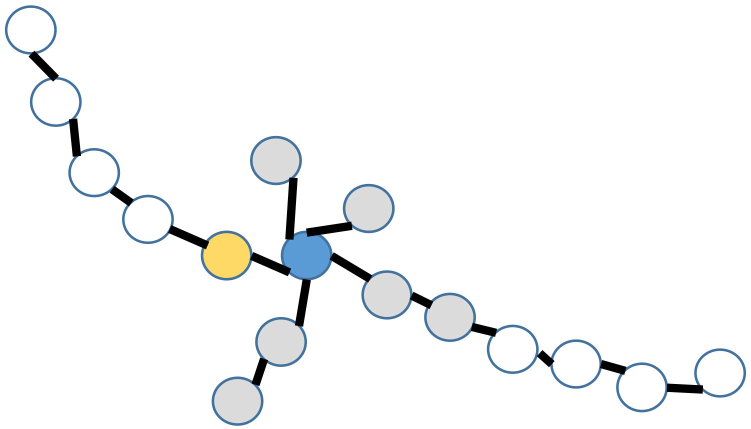

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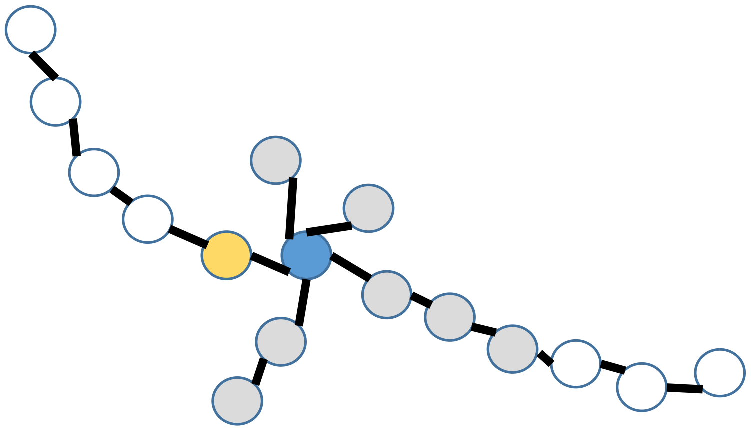

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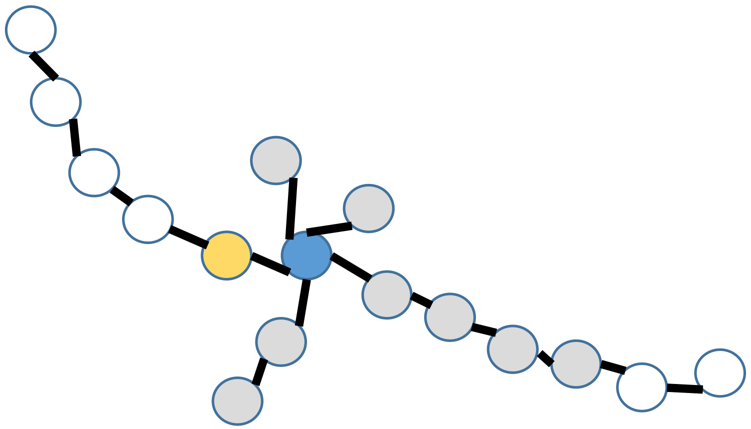

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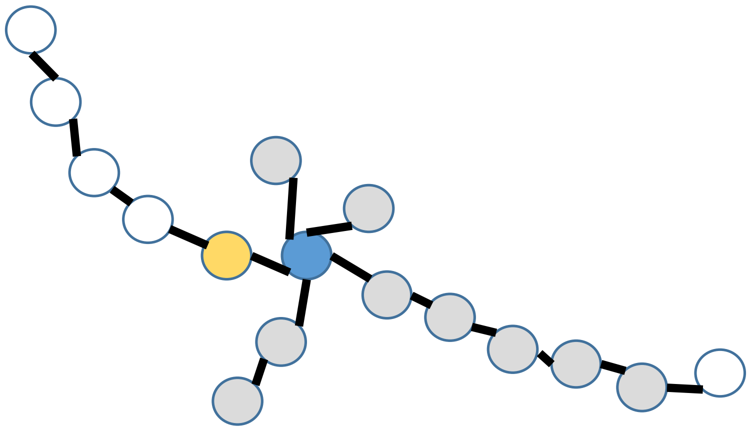

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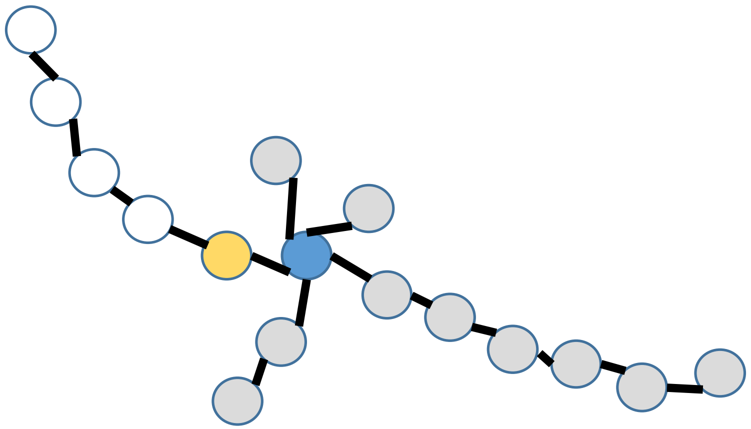

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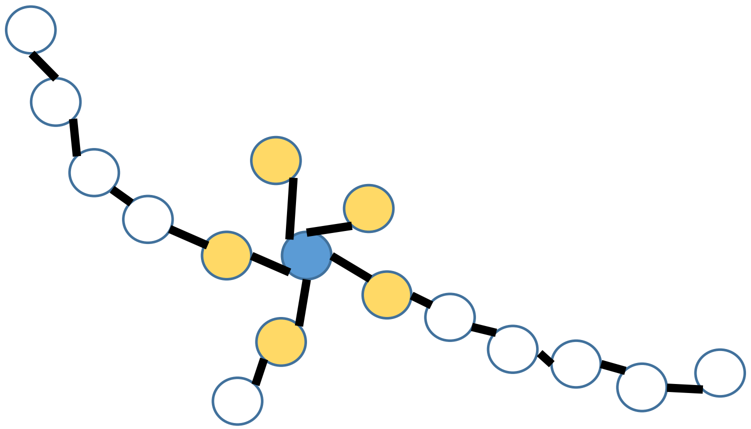

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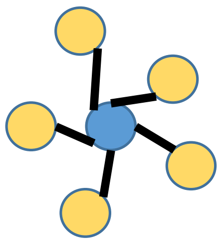

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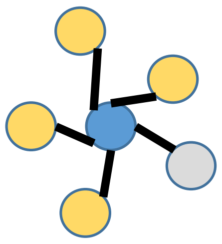

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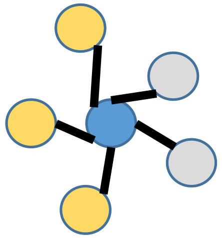

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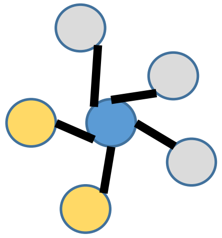

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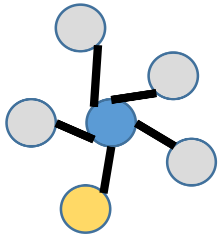

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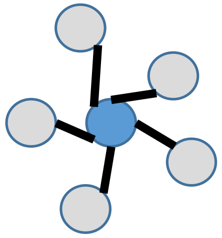

A bad example does not give you a good insight.

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