In [1]:
```
%matplotlib notebook

import os, sys
sys.path.insert(1, os.path.join(sys.path[0], '..'))
import database
from snowballing.operations import reload, work_by_varname, load_work_map_all_years
from snowballing.strategies import Strategy, State
import custom_strategies
from functools import reduce
from matplotlib_venn import venn2, venn2_circles
from matplotlib import pyplot as plt
import pandas as pd

custom_strategies.LIMIT_YEAR = 2015
reload()
# !pip install matplotlib-venn
```

In [2]:
```
from snowballing.operations import metakey, metakey_title

def busca(*libraries, seed=None, filter_function=None):
    filter_function = filter_function or (lambda x: x.category in ("snowball",))
    if seed is not None:
        iterable = ((1, work_by_varname(x)) for x in seed)
    else:
        iterable = load_work_map_all_years()
    seedset = set()
    visited = set()
    for _, work in iterable:
        for library in libraries:
            if int(getattr(work, library, 0)):
                visited.add(work)
                if filter_function(work):
                    seedset.add(work)
                break
    return seedset, filter_function, visited

def descreve_delta(strategy, state, name):
    target = state.find(name)
    previous_related = reduce(lambda x, y: x | y, (s.related for s in target.previous[0]), set())
    for work in previous_related:
        backward = set(strategy.ref[work]) & target.delta_visited
        if backward:
            print('backward', work.metakey)
            for ref in backward:
                print('-', ref.metakey, 'related' if ref in target.delta_related else '')
        forward = set(strategy.rev_ref[work]) & target.delta_visited
        if forward:
            print('forward', work.metakey)
            for ref in forward:
                print('-', ref.metakey, 'related' if ref in target.delta_related else '')

def separa_backward_forward(state):
    backward = set()
    forward = set()
    stack = [state]
    visited = {id(state)}
    while stack:
        current = stack.pop()
        if current.previous:
            if current.previous[1] == "backward":
```

```
                backward |= current.delta_related
            if current.previous[1] == "forward":
                forward |= current.delta_related

            antecessors = current.previous[0]
            for previous in antecessors:
                if id(previous) not in visited:
                    visited.add(id(previous))
                    stack.append(previous)
    return backward, forward

def encontraria(strategy, state):
    backward = set()
    forward = set()
    related = state.related - state.find("s0").related
    for work in state.related:
        backward |= (set(strategy.ref[work]) & related)
        forward |= (set(strategy.rev_ref[work]) & related)
    return backward, forward

#busca("scopus", seed=["wohlin2014a", "briand2000a"], filter_function=lambda x: True)
#busca("scopus", filter_function=lambda x: False)
```

1 Estratégias

1.1 Estratégia 1 - Busca em todas Digital Libraries (DL)

In [3]:
```
print ("Total de estudos primários usados como Seed Set: ", len ([x for _, x in load_work_map_all_years() if x.category == "snow
```

```
Total de estudos primários usados como Seed Set:  22
```

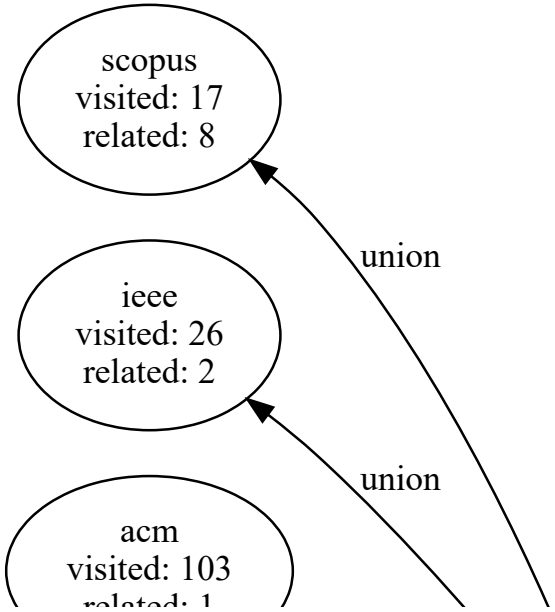
In [4]:
```
print ("Lista de estudos primários usados como Seed Set:")
([x for _, x in load_work_map_all_years() if x.category == "snowball"])
```

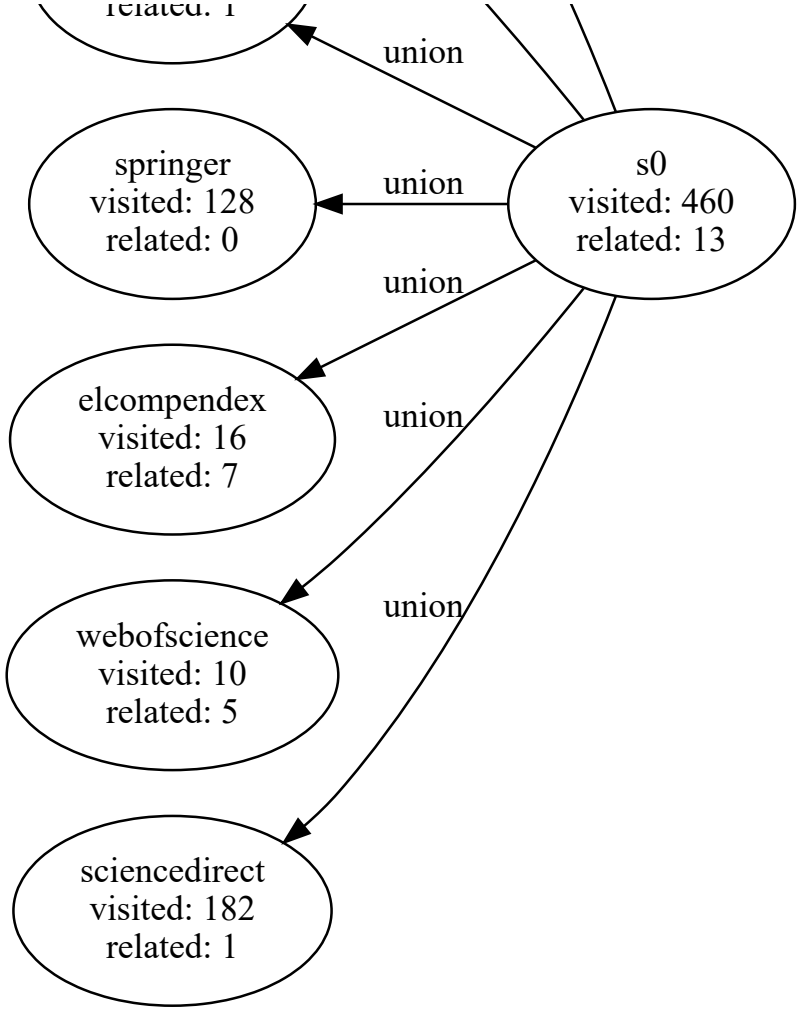
```
Lista de estudos primários usados como Seed Set:
```

Out[4]:
```
[Exploring the use of the cynefin framework to inform software development approach decisions,
 An elicitation instrument for operationalising GQM+ Strategies (GQM+ S-EI),
 Strategically balanced process adoption,
 Application of GQM+ Strategies{        extregistered} in the Japanese space industry,
 Software engineering strategies: aligning software process improvement with strategic goals,
 Defining and monitoring strategically aligned software improvement goals,
 Linking software development and business strategy through measurement,
 Integration of strategic management, process improvement and quantitative measurement for managing the competitiveness of sof
tware engineering organizations,
 Utilizing GQM+ Strategies for an organization-wide earned value analysis,
 Utilizing GQM+ Strategies for business value analysis: An approach for evaluating business goals,
 Software process improvement: Supporting the linking of the software and the business strategies,
 Entropy based software processes improvement,
 An approach to support the strategic alignment of software process improvement programs,
 Strategic alignment of software process improvement programs using QFD,
 ProPAMet: a Metric for process and project alignment,
 A Low-overhead method for software process appraisal,
 Business-oriented process improvement: practices and experiences at Thales Naval The Netherlands (TNNL),
 Measuring and improving software process in China,
 A business goal-based approach to achieving systems engineering capability maturity,
 Applying and adjusting a software process improvement model in practice: the use of the IDEAL model in a small software enter
prise,
 Managing process inconsistency using viewpoints,
 SPI:□I can't get no satisfaction□-directing process improvement to meet business needs]
```

In [5]:
```
reload()
TOTAL = [x for _, x in load_work_map_all_years() if x.category == "snowball"]
filter_function = lambda x: x.category in ("snowball", "forward", "backward")
```

In [6]:
```
from snowballing.strategies import State

reload()
def busca_completa(libs, filter_function):
    union = None
    for dl in libs:
        strategy = Strategy(*busca(dl, filter_function=filter_function))
        strategy.initial.name = dl
        if union is None:
            union = strategy.initial.derive("union", name="s0")
        else:
            union.visited.update(strategy.initial.visited)
            union.related.update(strategy.initial.related)
            union.previous[0].append(strategy.initial)

    State.last_id = 0
    strategy.initial = union
    return strategy

strategy = busca_completa(["scopus", "ieee", "acm", "springer", "elcompendex", "webofscience", "sciencedirect"], filter_function
#strategy.initial.find("acm")
strategy.initial
```



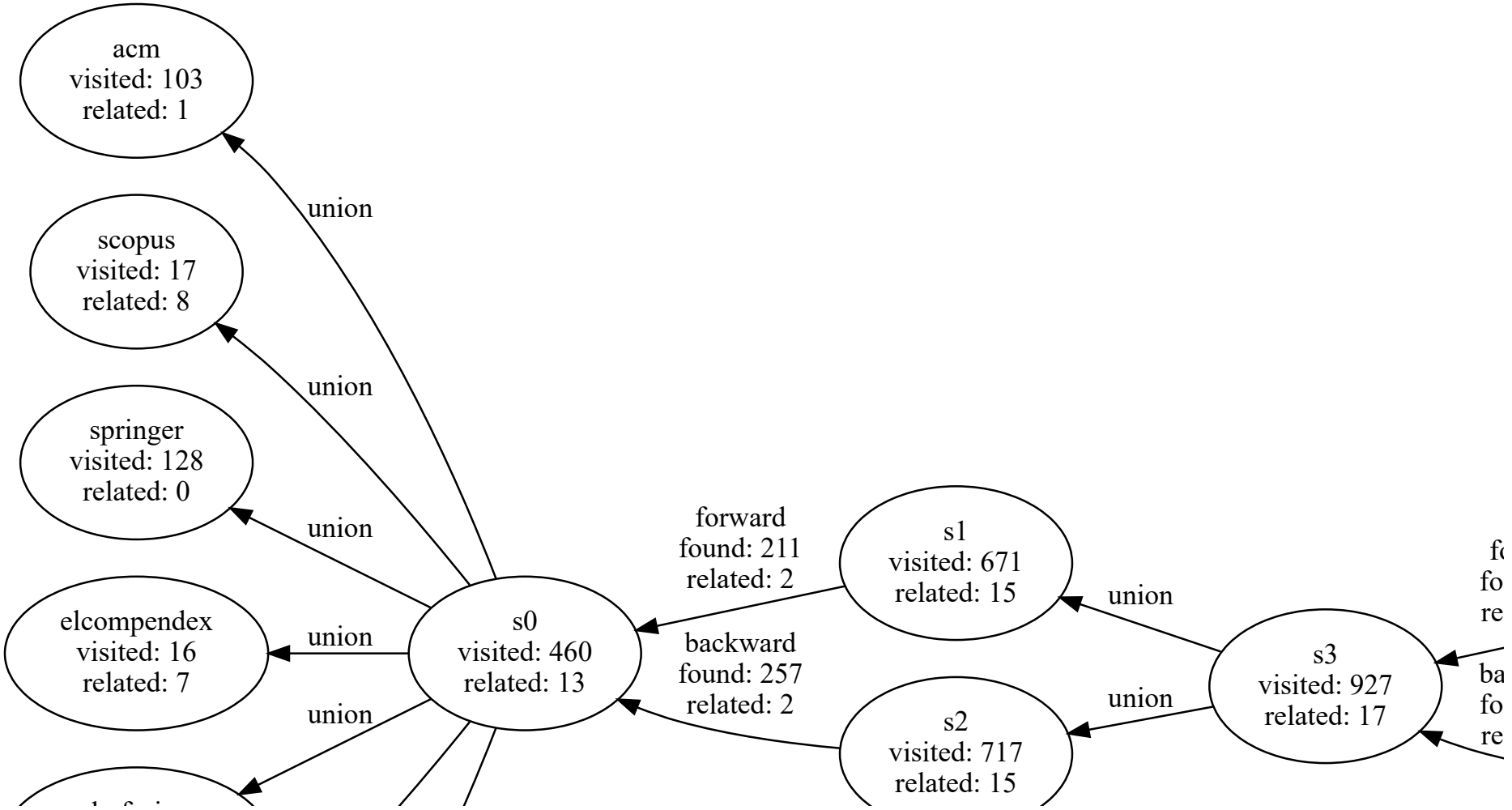

related: 1
union
springer
visited: 128
related: 0
union
s0
visited: 460
related: 13
union
elcompendex
visited: 16
related: 7
union
webofscience
visited: 10
related: 5
union
sciencedirect
visited: 182
related: 1

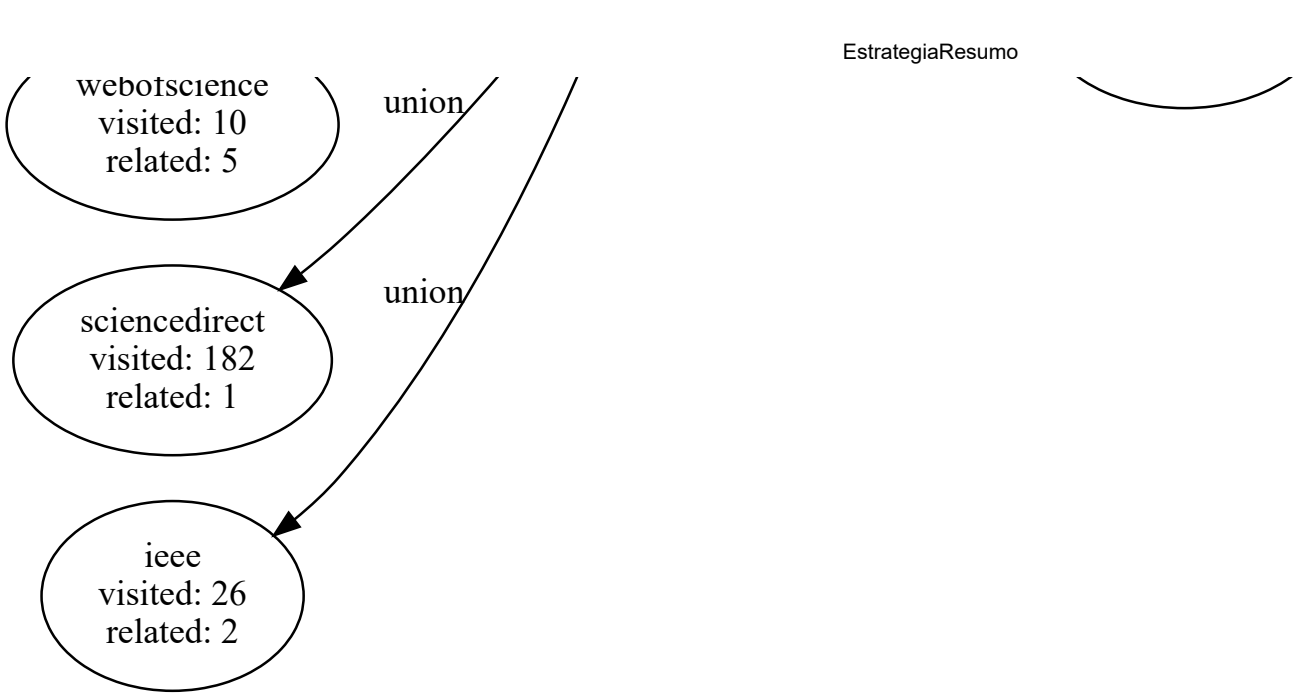
In [7]:
```
array = []

name = "E1"
print ("Precision " + name)
EP = len (strategy.initial.related) / len (strategy.initial.visited)
print (EP)
print ("Recall " + name)
ER = len (strategy.initial.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E1
0.02826086956521739
Recall E1
0.5909090909090909
```

1.2 Estratégia 2 - Busca em todas Digital Libraries + Snowballing (Guideline - sfbu)

In [8]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = busca_completa(["acm", "scopus", "springer", "elcompendex", "webofscience", "sciencedirect", "ieee"], filter_function
#Strategy(*busca("acm","scopus", filter_function=filter_function))

state = strategy.sfbu()
#state = strategy.bbff()
#state = strategy.ffbb()
#state = strategy.s2ffbb2u()

state
```





In [9]:
```
def duplicados(strategy, state):
    encontrados = set()
    result = set()
    soma = 0
    related = state.related - state.find("s0").related
    for work in state.related:
        inter = encontrados & (set(strategy.ref[work]) & related)
        if inter:
            soma += len(inter)
            encontrados |= inter
            print(work @ metakey, "backward", inter @ metakey)
        inter = encontrados & (set(strategy.rev_ref[work]) & related)
        if inter:
            soma += len(inter)
            encontrados |= inter
            print(work @ metakey, "forward", inter @ metakey)
    return soma
```

In [10]:
```
sets = separa_backward_forward(state)
sets = encontraria(strategy, state)
v = venn2(sets, set_labels = ('Backward', 'Forward'))
c = venn2_circles(sets)
plt.title('Diagrama de Venn')
plt.show()
```

In [11]:
```
#Backward - Execução de backward em sets[0]
print("Backward", sets[0] @ metakey)
print("Forward", sets[1] @ metakey)
```

```
Backward ['trienekens2009a', 'becker2008b']
Forward ['petersen2015a', 'mandić2010a']
```

1.2.0.1 Resumo do Precision e Recall

In [12]:
```
E2P = len (strategy.initial.related) / len (strategy.initial.visited)
#print (len (strategy.initial.related))
#print (len (strategy.initial.visited))
#print (E2P)
print ("Precision na Busca E2: %.2f%%" % E2P)

#print ("Precision no Snowballing - E2:")
#print(len(state.related - state.find("s0").related))
#print(len(state.visited - state.find("s0").visited))

E2PS = len(state.related - state.find("s0").related) / len(state.visited - state.find("s0").visited)

print ("\n""Precision no Snowballing E2: %.2f%%" % E2PS)

print("Precision no Snowballing E2 - Forward - 1 iteração: %.2f%%" % (len (state.find("s1").delta_related) / len (state.find("s1

print("Precision no Snowballing E2 - Backward - 1 iteração: %.2f%%" % (len (state.find("s2").delta_related) / len (state.find("s

print("\n""Precision E2 (Busca + Snowballing): %.2f%%" % (len(state.related) / len(state.visited)))

#len (state.find("s1").related)

#len (state.find("s1").delta_related)
#len (state.find("s1").delta_visited)


name = "E2"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision na Busca E2: 0.03%

Precision no Snowballing E2: 0.01%
Precision no Snowballing E2 - Forward - 1 iteração: 0.01%
Precision no Snowballing E2 - Backward - 1 iteração: 0.01%
```

```
Precision E2 (Busca + Snowballing): 0.02%
Precision E2
0.016748768472906402
Recall E2
0.7727272727272727
```

In [13]:
```
from collections import deque
def precision_recall(state, total, stop=""):
    # Precisao 0 quando nao visita nada
    array = [[
        "state", "precision", "recall", "operation",
        "related", "visited", "delta_related", "delta_visited",
        "accumulated_precision", "accumulated_recall",
    ]]
    stack = deque([state])
    visited = {id(state)}
    while stack:
        current = stack.pop()
        try:
            accumulated_precision = len(current.related) / len(current.visited)
            precision = len(current.delta_related) / len(current.delta_visited)
        except ZeroDivisionError:
            precision = 0.0

        array.append([
            current.name,
            precision,
            len(current.delta_related) / len(total),
            current.previous[1] if current.previous else "-",
            len(current.related),
            len(current.visited),
            len(current.delta_related),
            len(current.delta_visited),
            accumulated_precision,
            len(current.related) / len(total),
        ])
        if current.name == stop:
            break
        if current.previous:
            antecessors = current.previous[0]
            for previous in antecessors:
                if id(previous) not in visited:
                    visited.add(id(previous))
                    stack.appendleft(previous)
    return array
```

In [14]:
```
df = pd.DataFrame(list(reversed(precision_recall(state, TOTAL))))
df.columns = df.iloc[-1]
df = df.drop(df.index[-1])
df
```

Out[14]:

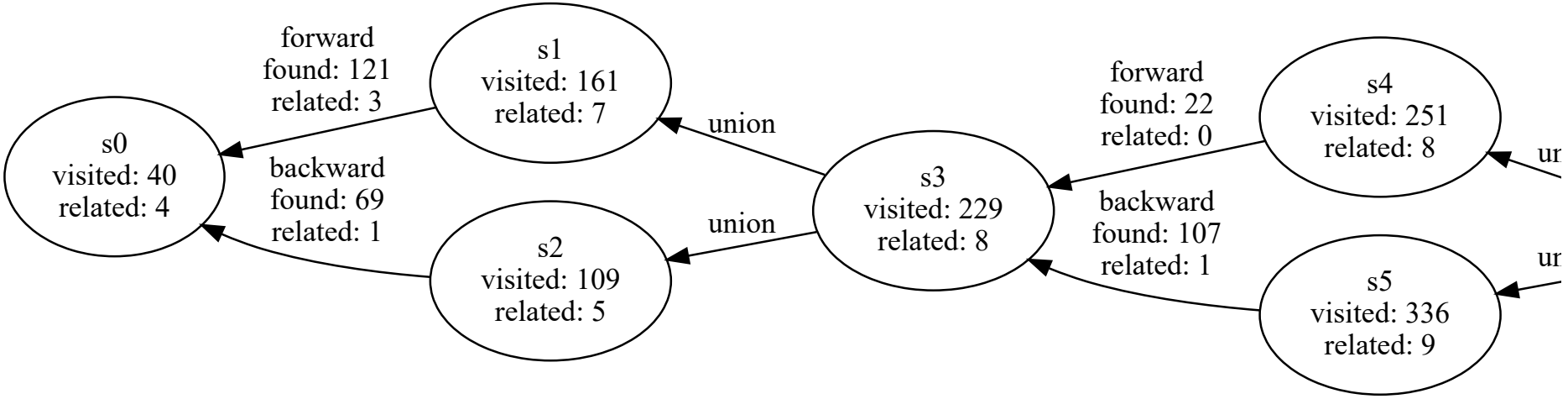
14	state	precision	recall	operation	related	visited	delta_related	delta_visited	accumulated_precision	accumulated_recall
0	ieee	0.0769231	0.0909091	-	2	26	2	26	0.0769231	0.0909091
1	sciencedirect	0.00549451	0.0454545	-	1	182	1	182	0.00549451	0.0454545
2	webofscience	0.5	0.227273	-	5	10	5	10	0.5	0.227273
3	elcompendex	0.4375	0.318182	-	7	16	7	16	0.4375	0.318182
4	springer	0	0	-	0	128	0	128	0	0
5	scopus	0.470588	0.363636	-	8	17	8	17	0.470588	0.363636
6	acm	0.00970874	0.0454545	-	1	103	1	103	0.00970874	0.0454545
7	s0	0	0	union	13	460	0	0	0.0282609	0.590909
8	s2	0.0077821	0.0909091	backward	15	717	2	257	0.0209205	0.681818
9	s1	0.00947867	0.0909091	forward	15	671	2	211	0.0223547	0.681818
10	s3	0	0	union	17	927	0	0	0.0183387	0.772727
11	s5	0	0	backward	17	986	0	59	0.0172414	0.772727
12	s4	0	0	forward	17	956	0	29	0.0177824	0.772727
13	s6	0	0	union	17	1015	0	0	0.0167488	0.772727

In [15]:
```
fig = plt.figure()
df['precision'].plot(legend=True)
df['recall'].plot(legend=True)
ax = plt.gca()
ax.set_xticklabels(df["state"] + "\n" + df["operation"])
ax.set_title("By State");
```

In [16]:
```
fig = plt.figure()
df['accumulated_precision'].plot(legend=True)
df['accumulated_recall'].plot(legend=True)
ax = plt.gca()
ax.set_xticklabels(df["state"] + "\n" + df["operation"])
ax.set_title("Accumulated");
```

1.3 Estratégia 3 - Busca Informal (Google Scholar) + Snowballing (Guideline - sfbu)

In [17]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = Strategy(*busca("gs", filter_function=filter_function))
state = strategy.sfbu()
state
```

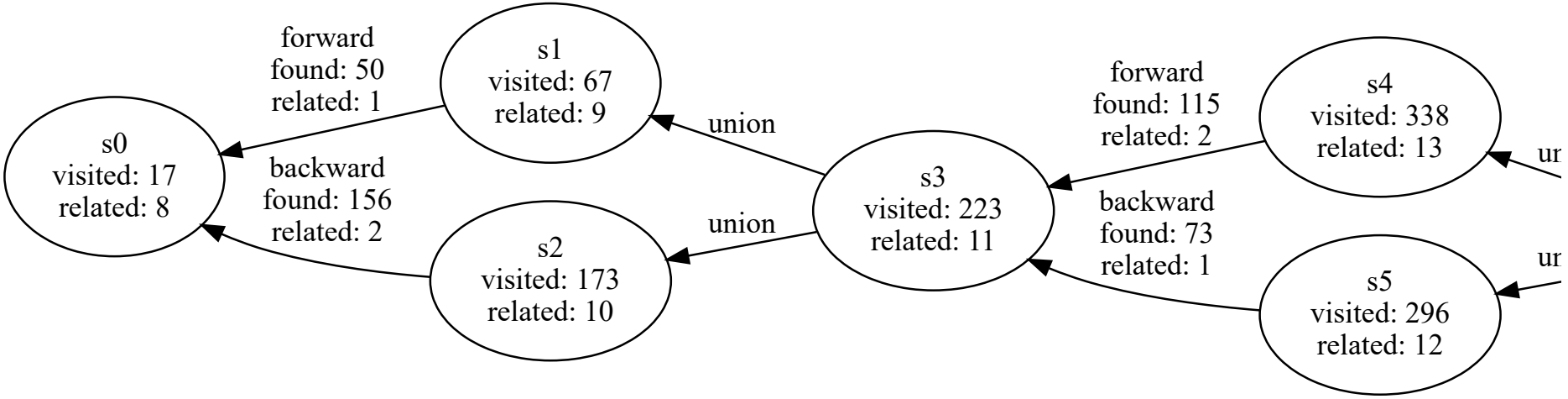


In [18]:
```
name = "E3"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E3
0.02313624678663239
Recall E3
0.4090909090909091
```

1.4 Estratégia 4 - Busca em Scopus + Snowballing (Guideline - sfbu)

In [19]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = Strategy(*busca("scopus", filter_function=filter_function))

#from copy import copy
#strategy.initial.visited = copy(strategy.initial.related)
state = strategy.sfbu()
state
```

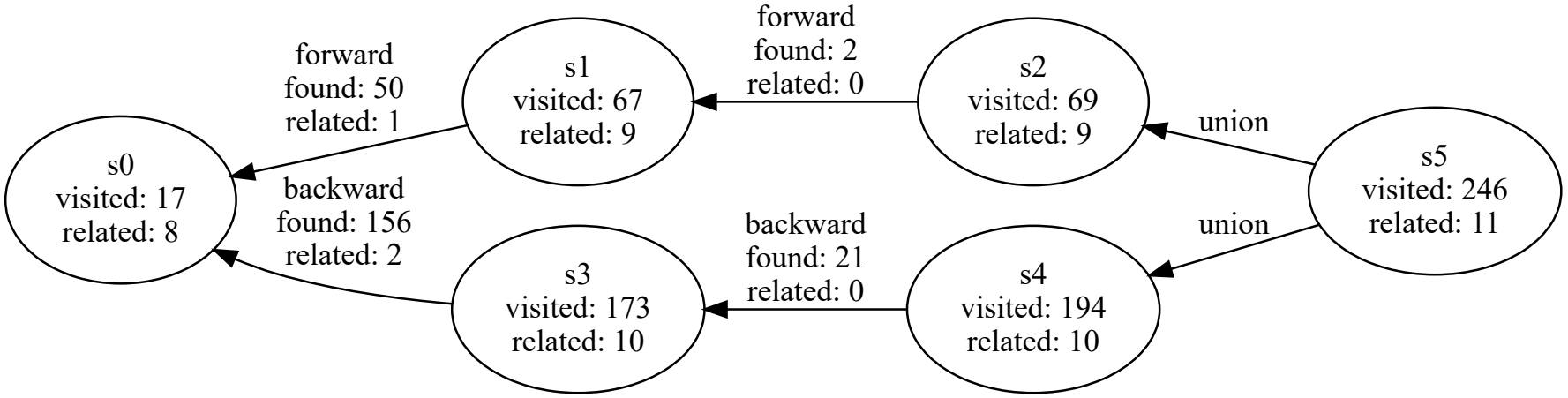


In [20]:
```
name = "E4"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E4
0.029345372460496615
Recall E4
0.5909090909090909
```

1.5 Estratégia 5 - Busca em Scopus + Snowballing (Short Paper - s2ffbb2u)

In [21]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = Strategy(*busca("scopus", filter_function=filter_function))
state = strategy.s2bbff2u()
state
```

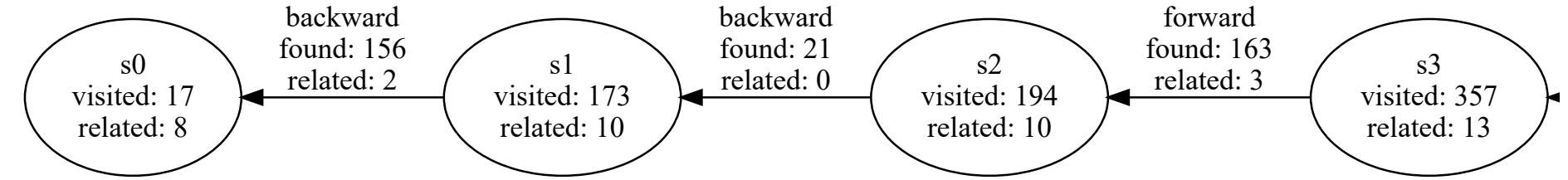


In [22]:
```
name = "E5"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E5
0.044715447154471545
Recall E5
0.5
```

1.6 Estratégia 6 - Busca em Scopus + Snowballing (JF - bbff)

In [23]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = Strategy(*busca("scopus", filter_function=filter_function))
state = strategy.bbff()
state
```

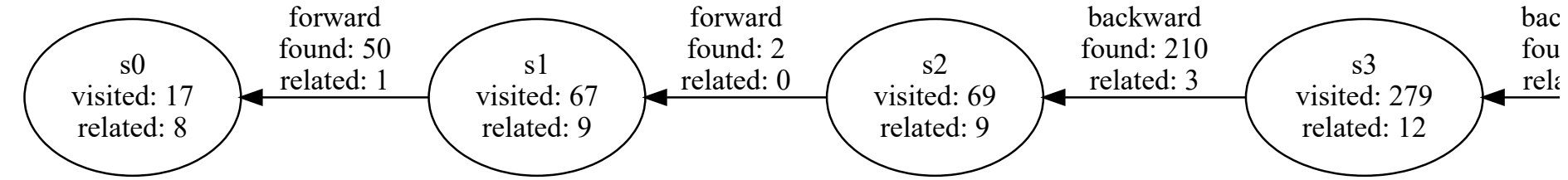


In [24]:
```
name = "E6"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E6
0.03513513513513514
Recall E6
0.5909090909090909
```

1.7 Estratégia 7 - Busca em Scopus + Snowballing (JF - ffbb)

In [25]:
```
reload()
filter_function = lambda x: x.category in ("snowball", "forward", "backward")

strategy = Strategy(*busca("scopus", filter_function=filter_function))
state = strategy.ffbb()
state
```



In [26]:
```
name = "E7"
print ("Precision " + name)
EP = len (state.related) / len (state.visited)
print (EP)
print ("Recall " + name)
ER = len (state.related) / len (TOTAL)
print (ER)

array.append((name, EP, ER))
```

```
Precision E7
0.037037037037037035
Recall E7
0.5454545454545454
```

2 Análise das Estratégias

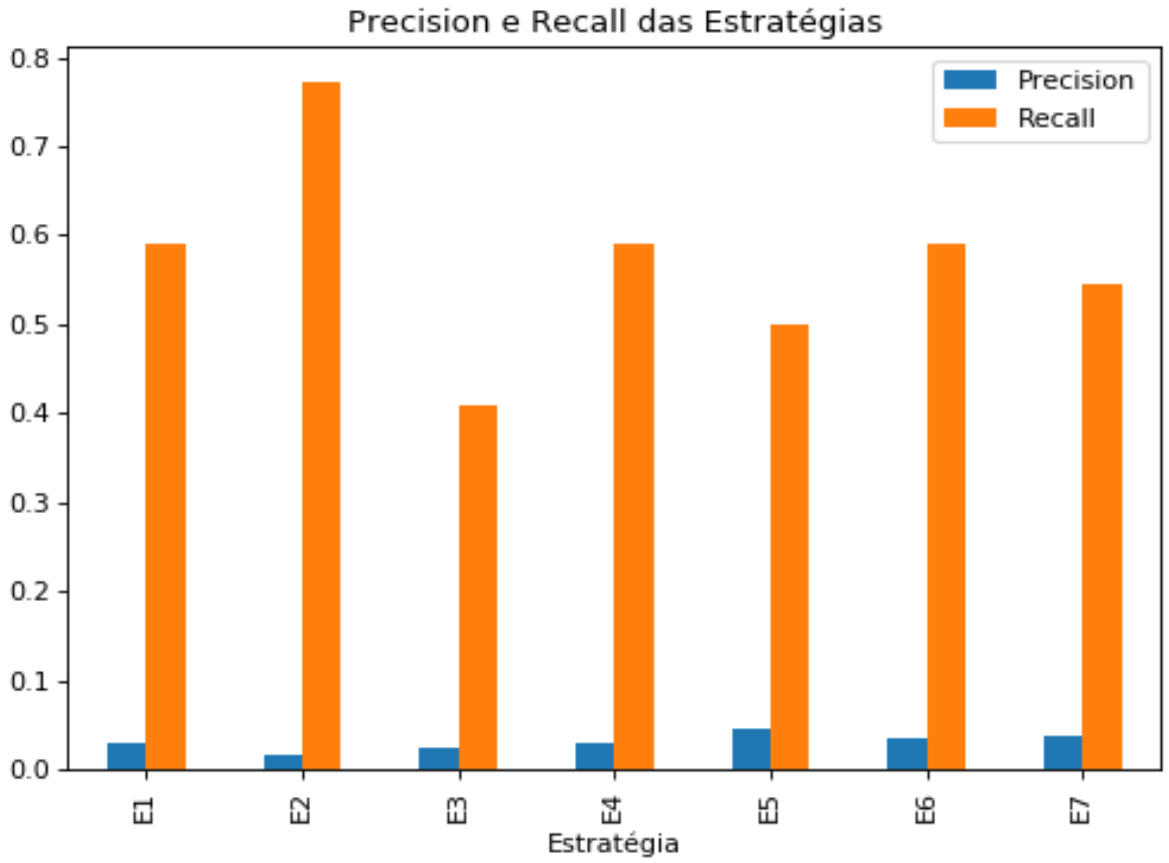
In [27]:
```
%matplotlib notebook
import pandas as pd
```

In [28]:
```
df = pd.DataFrame (array,columns = ['Estratégia','Precision','Recall'])
df.index = df['Estratégia']
df
```

Out[28]:

Estratégia	Estratégia	Precision	Recall
E1	E1	0.028261	0.590909
E2	E2	0.016749	0.772727
E3	E3	0.023136	0.409091
E4	E4	0.029345	0.590909
E5	E5	0.044715	0.500000
E6	E6	0.035135	0.590909
E7	E7	0.037037	0.545455

In [29]:
```
import matplotlib.pyplot as plt
ax = df.plot.bar(title ="Precision e Recall das Estratégias")
plt.tight_layout()
```



In [30]:
```
df
```

Out[30]:

Estratégia	Estratégia	Precision	Recall
E1	E1	0.028261	0.590909
E2	E2	0.016749	0.772727
E3	E3	0.023136	0.409091
E4	E4	0.029345	0.590909
E5	E5	0.044715	0.500000
E6	E6	0.035135	0.590909
E7	E7	0.037037	0.545455