Horton's *Who Done It?*

Communicating Authority with Responsibility Tracking

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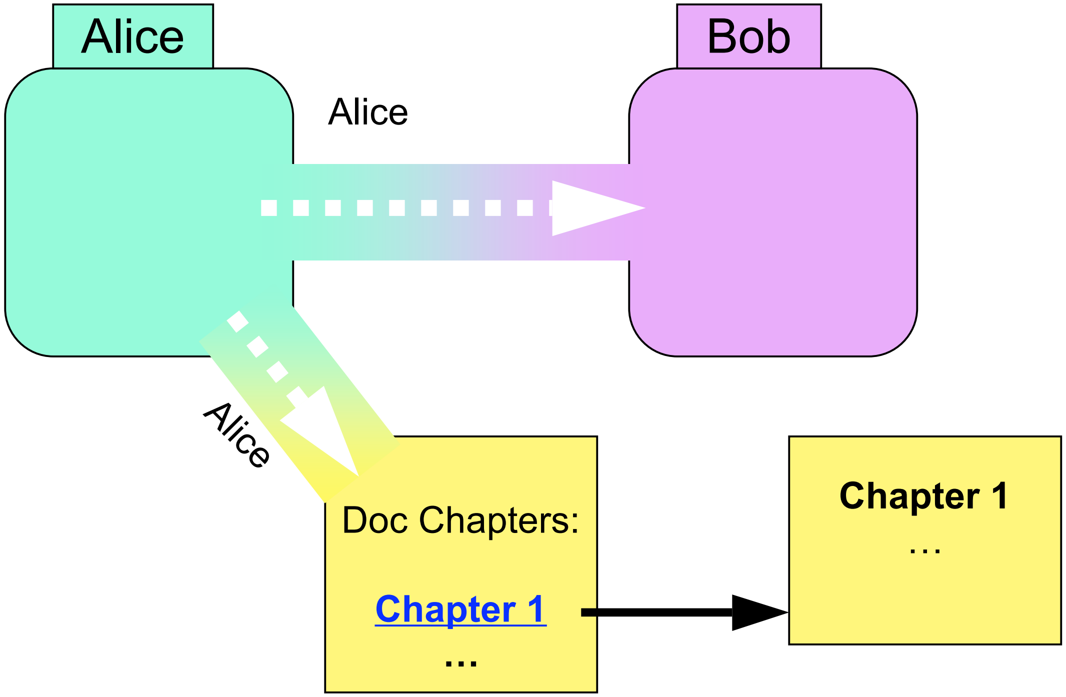
Alan H. Karp HP Labs

Usenix HotSec Workshop, August 7, 2007

[1] Work done while at HP Labs

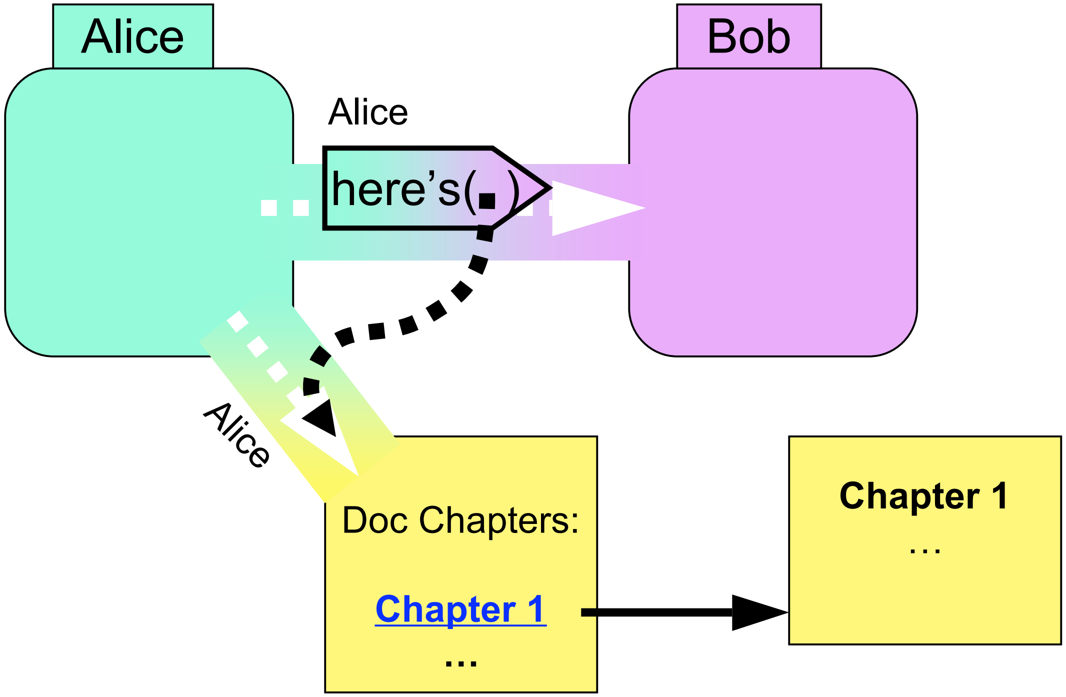
Communicating Object Access with Delegation



Initial Conditions:

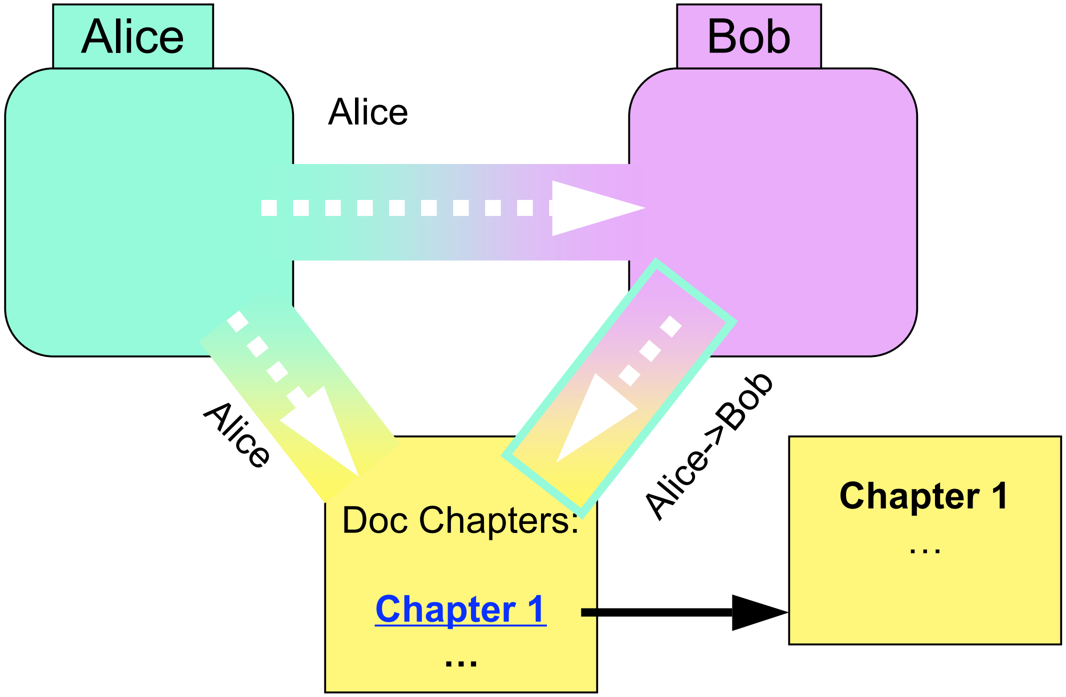
Alice has: 1. A capability to send to Bob and
2. A capability to a document with chapters.

Capability Communication of the Document Reference



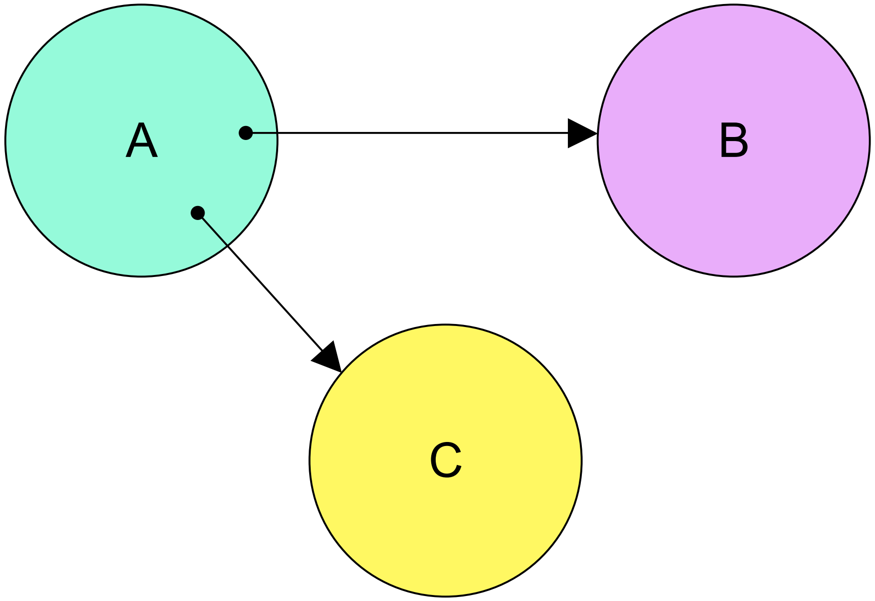
Alice sends a message to Bob containing a reference to the document.

Horton Magic: Bob Receives a Delegated Capability

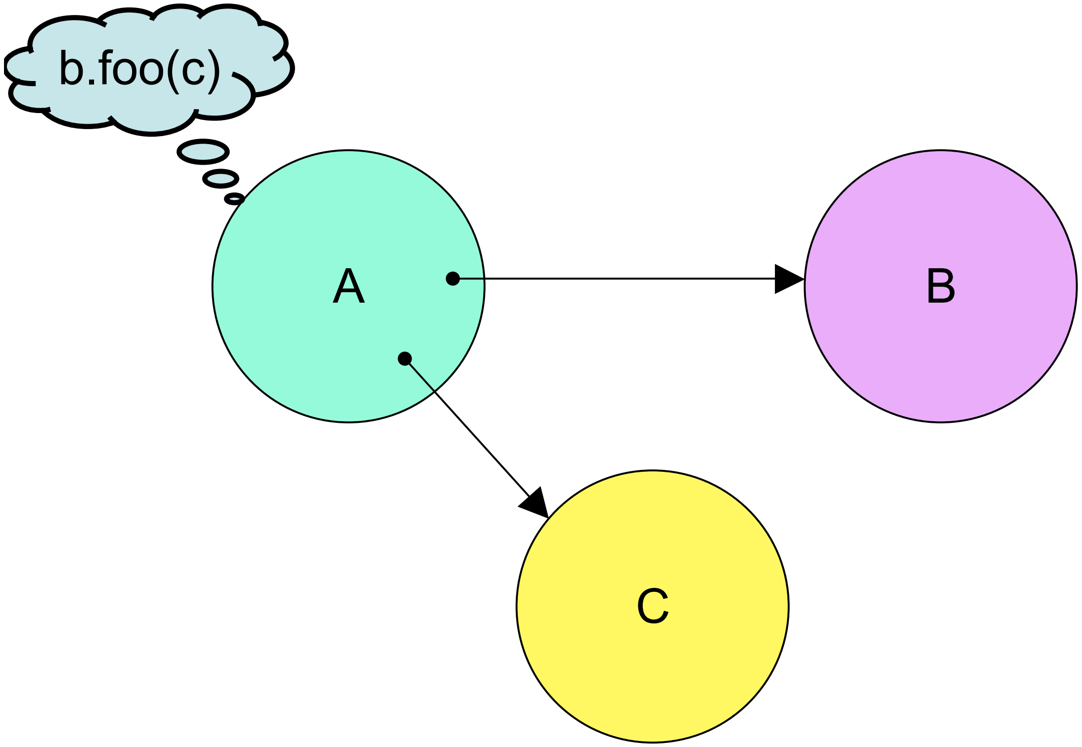


Alice can’t act with Bob’s responsibility
Bob can’t act with Alice’s responsibility

Delegating Least Authority



Delegating Least Authority



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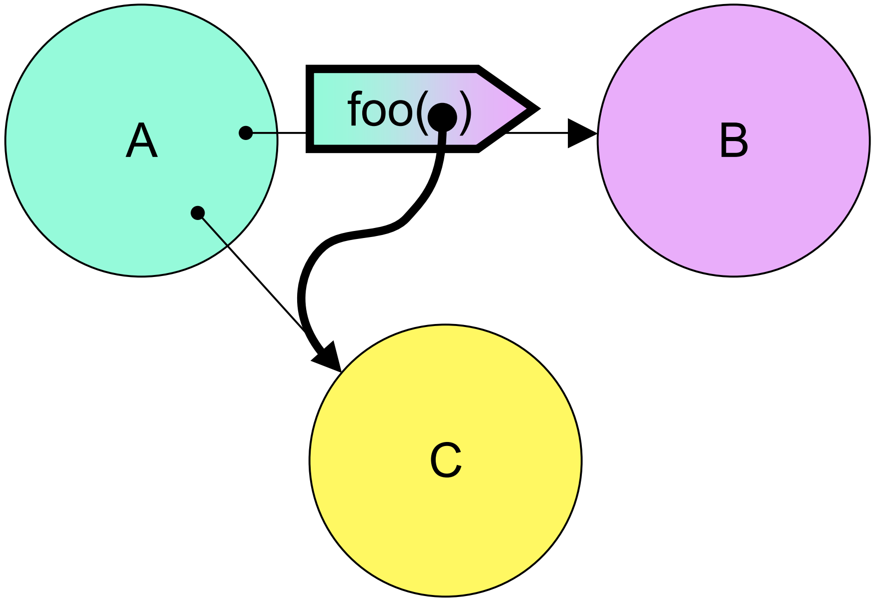
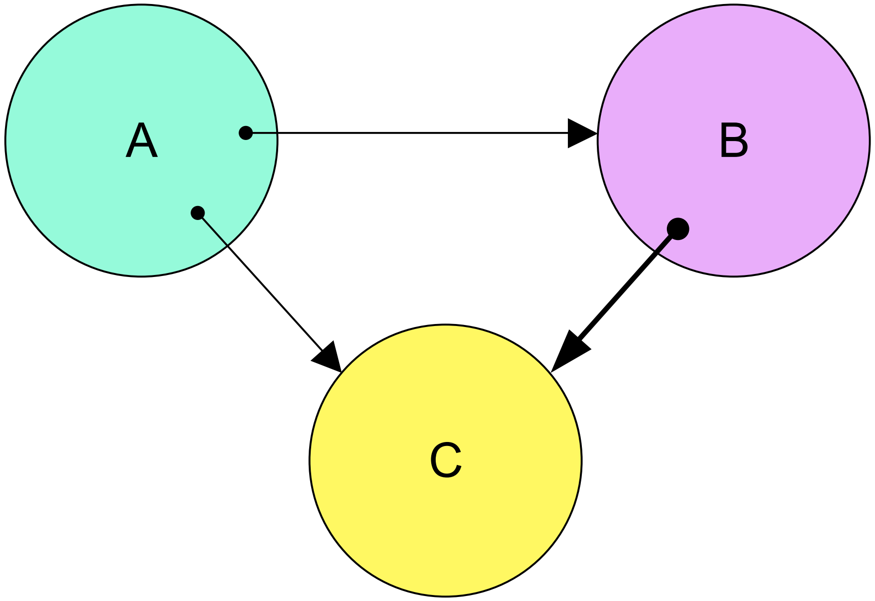
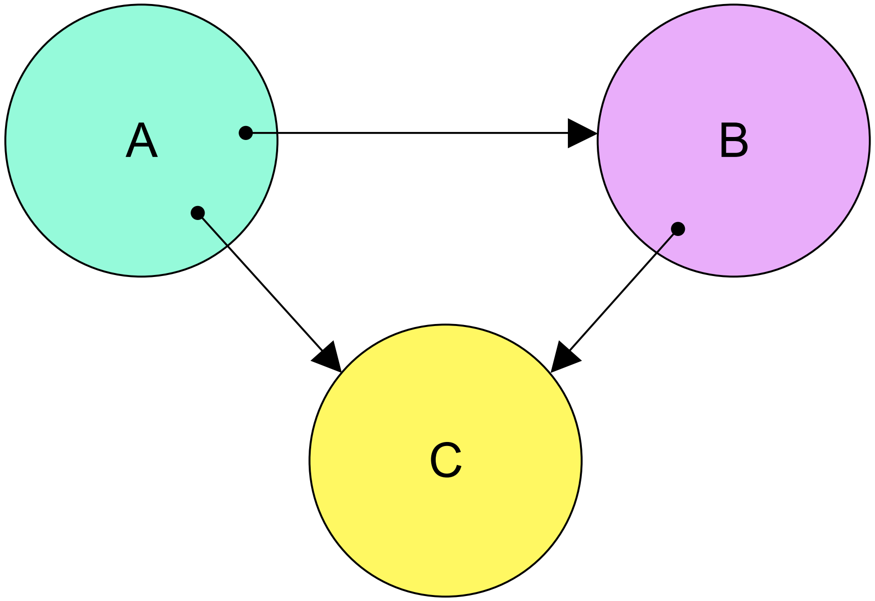


Delegating Least Authority

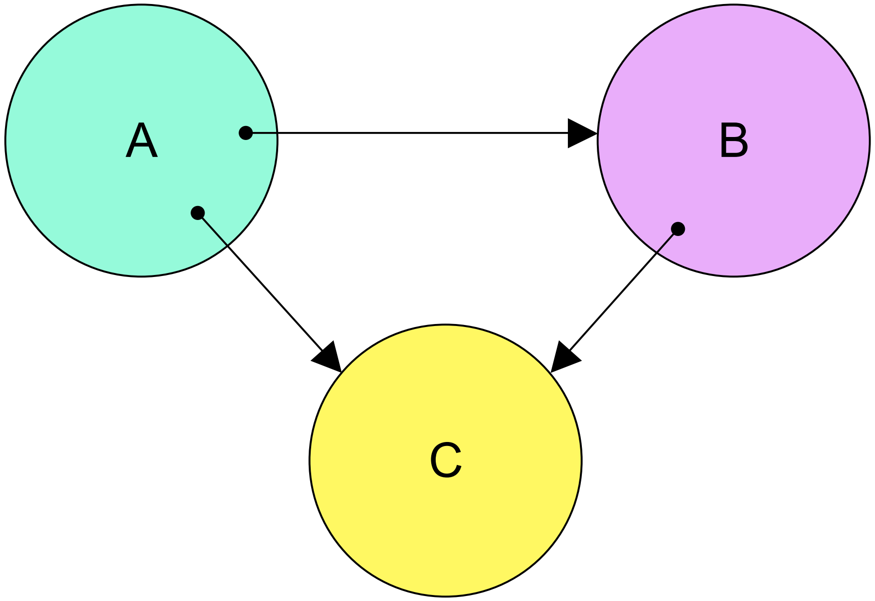


Delegating Least Authority



- Msgs are *only* means to cause effects
- Refs control authority
- Leverage OO patterns

Delegating Least Authority



- Msgs are *only* means to cause effects
- Refs control authority
- Leverage OO patterns
- Anonymous

Two styles, relative strengths

Program decisions		Human decisions
Fine-grained		Large-grained
Built for safety		Built for damage control
Least authority		Most responsibility
Virus resistant		Spam resistant
Authorization-based		Identity-based
↓	?	↓
Object-capabilities (ocaps)		ACLs

Two styles, relative strengths

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Polaris, Plash
Bitfrost?

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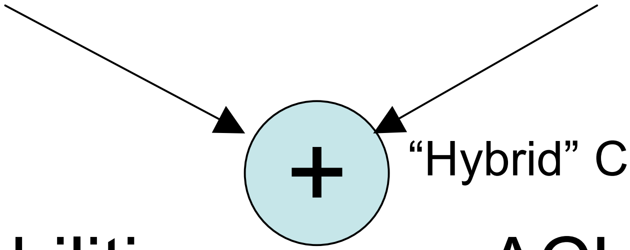

"Hybrid" Cap Systems (SCAP, Sys/38)

Object-capabilities (ocaps)	ACLs

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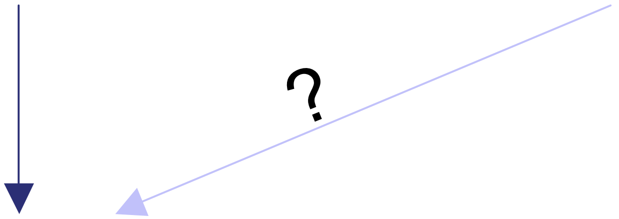

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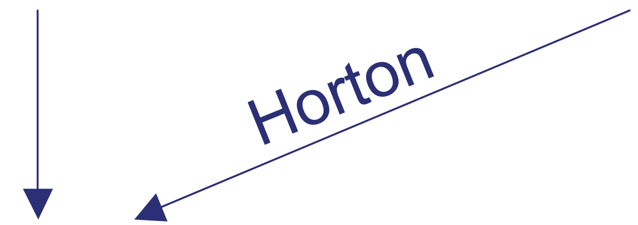
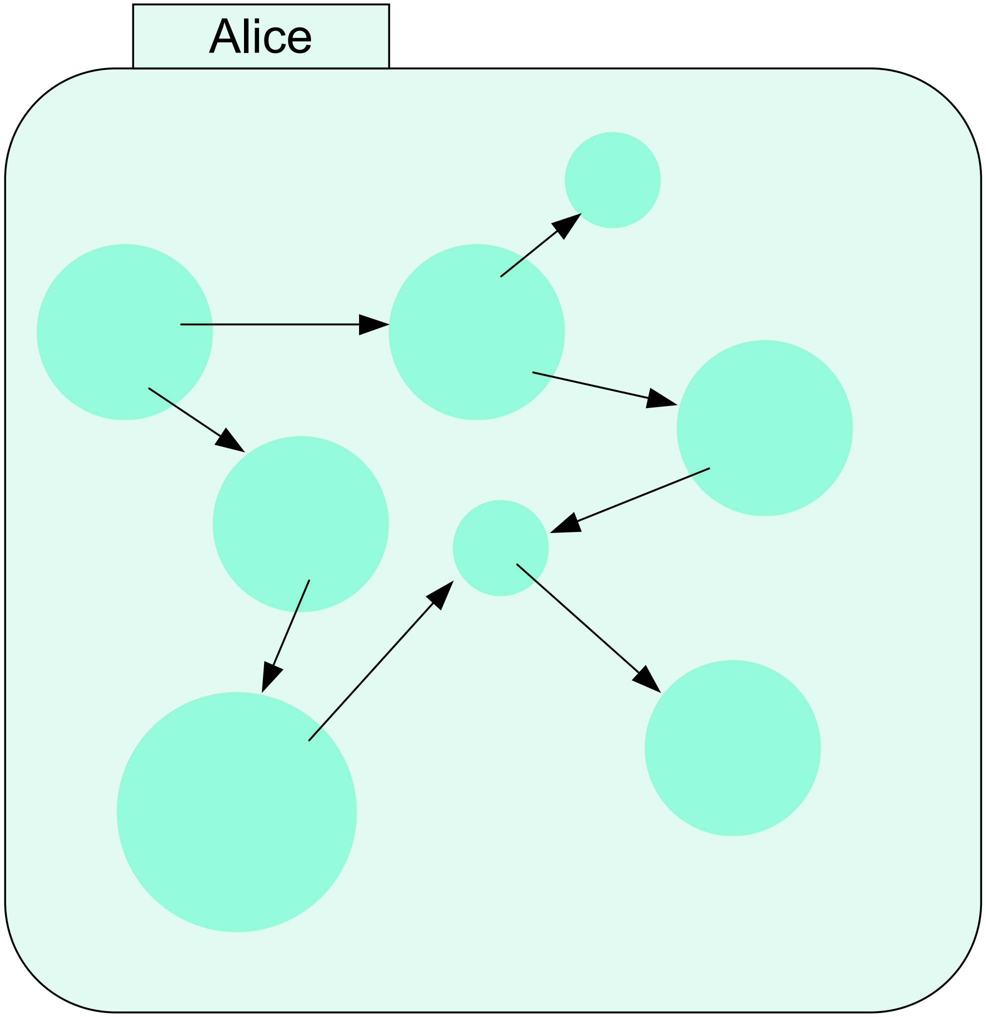
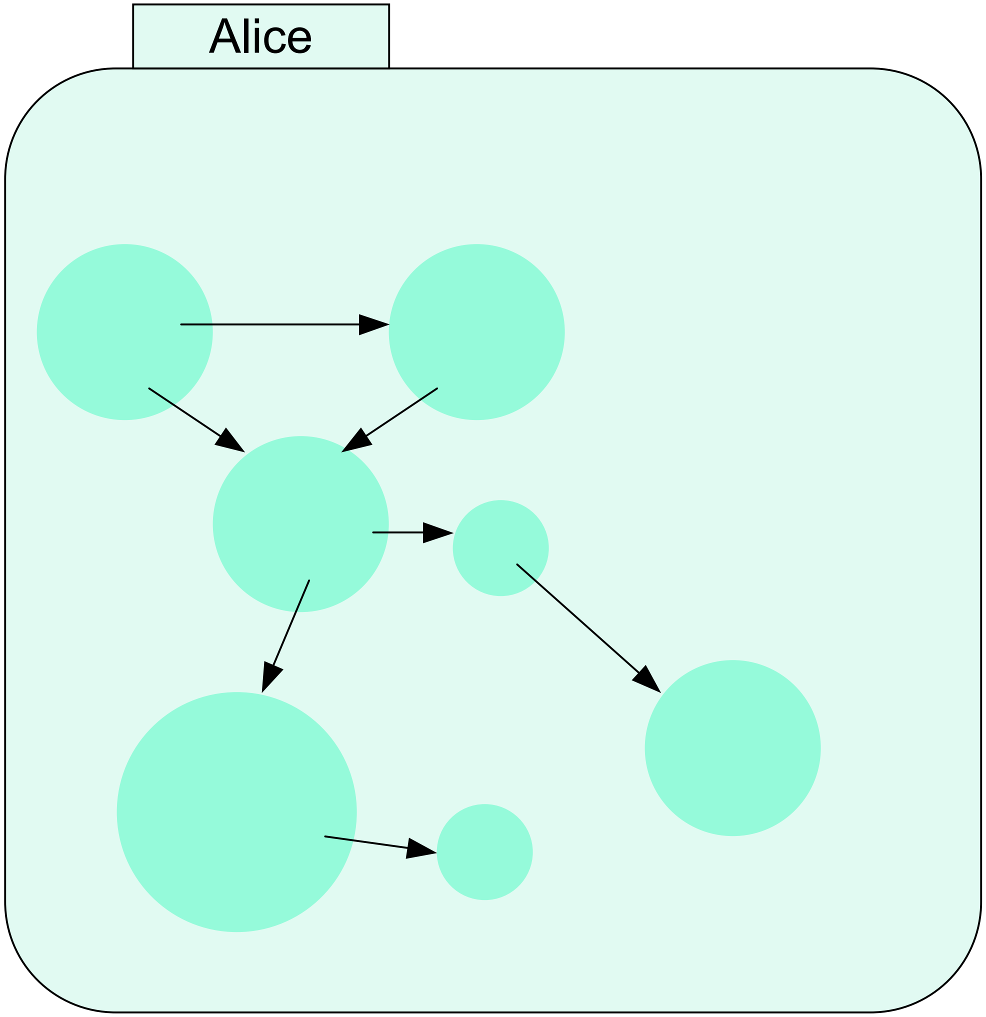


Object-capabilities
(ocaps)

ACLs



Can’t vet code or actions of each object.



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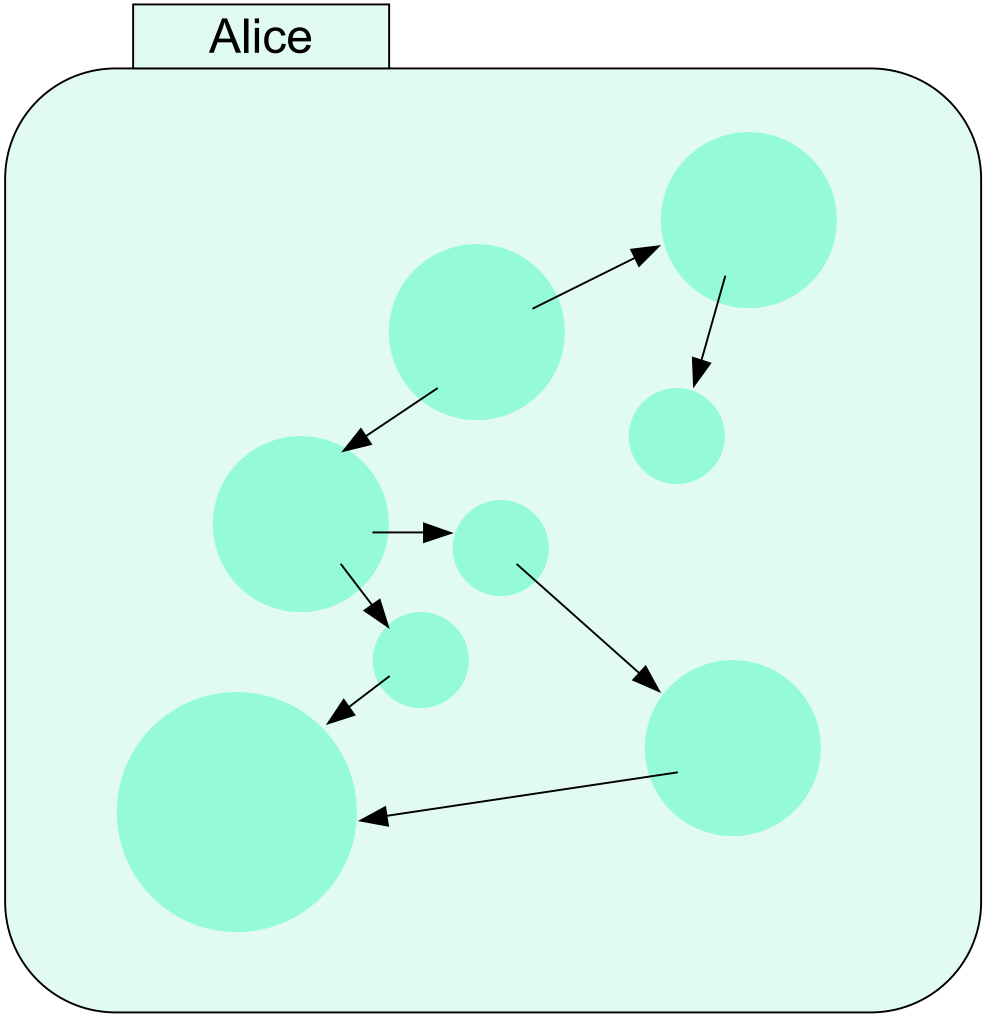

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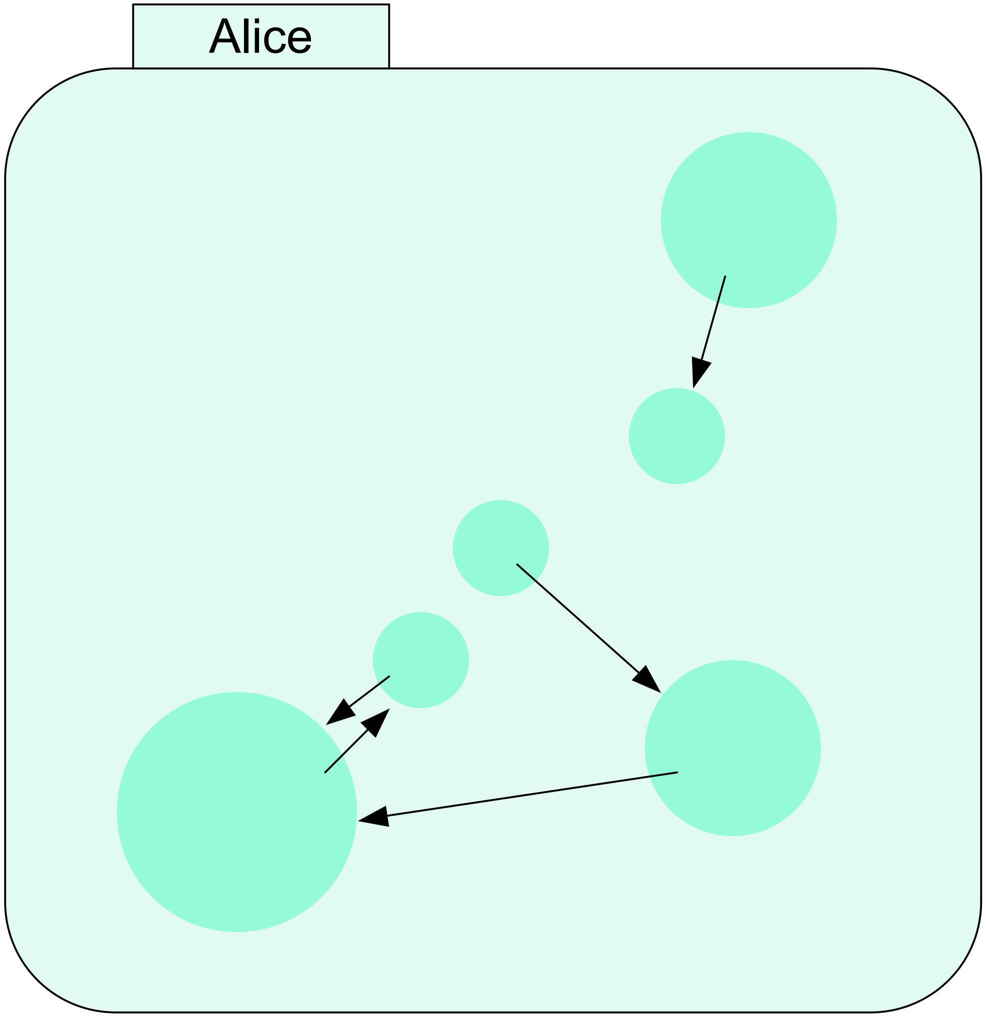
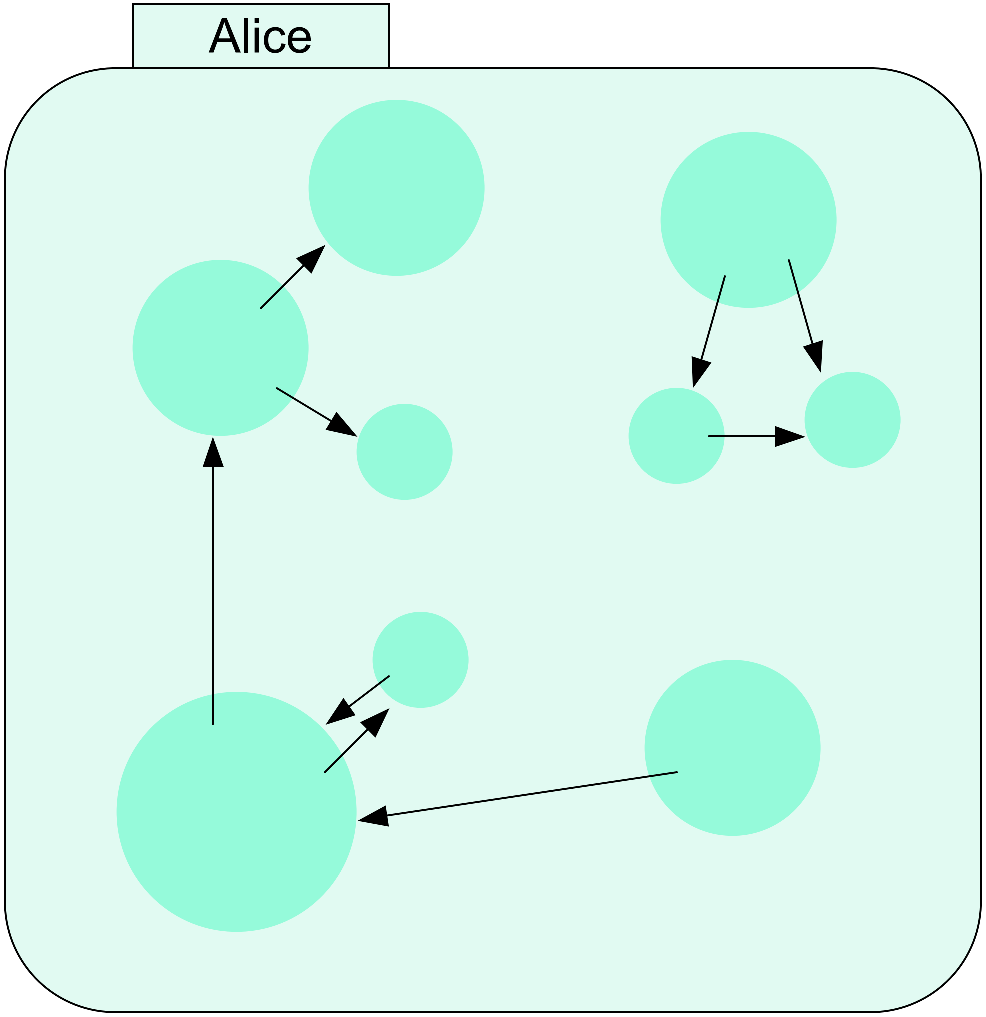


Can’t vet code or actions of each object.



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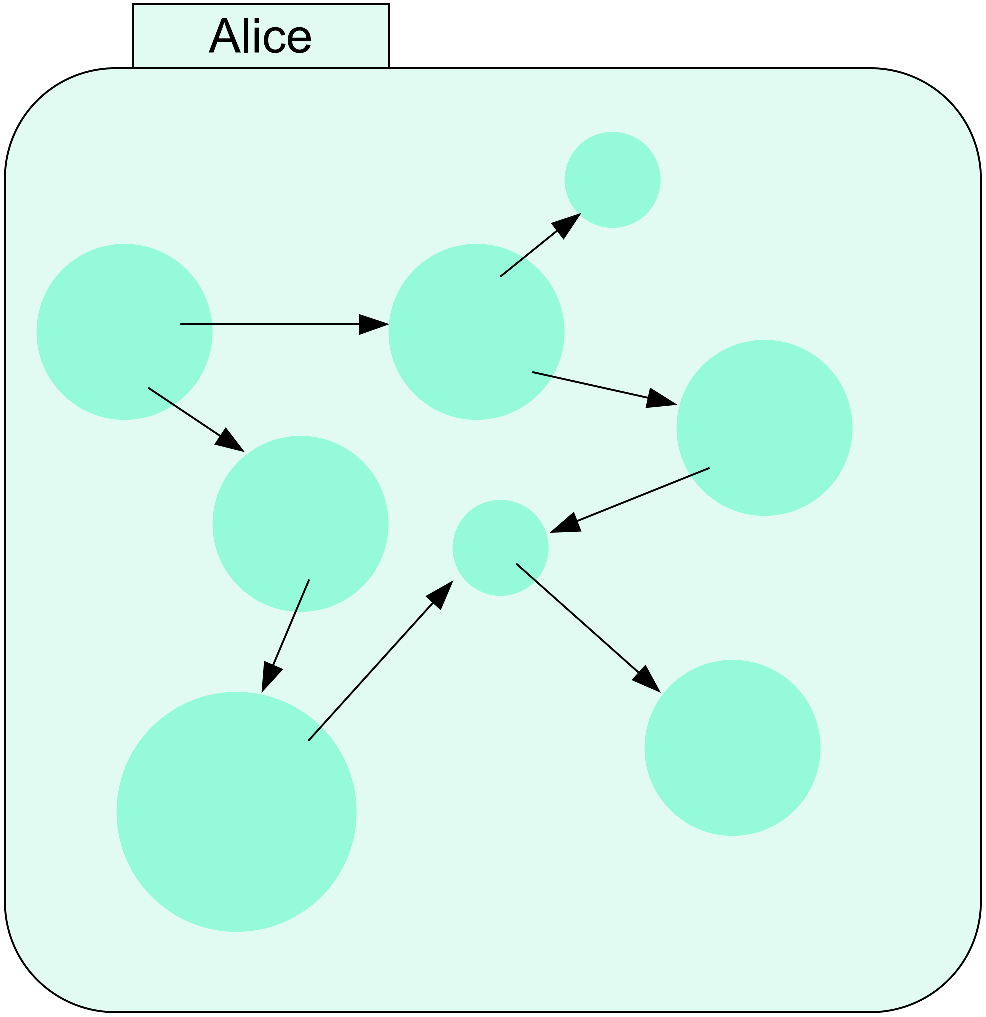

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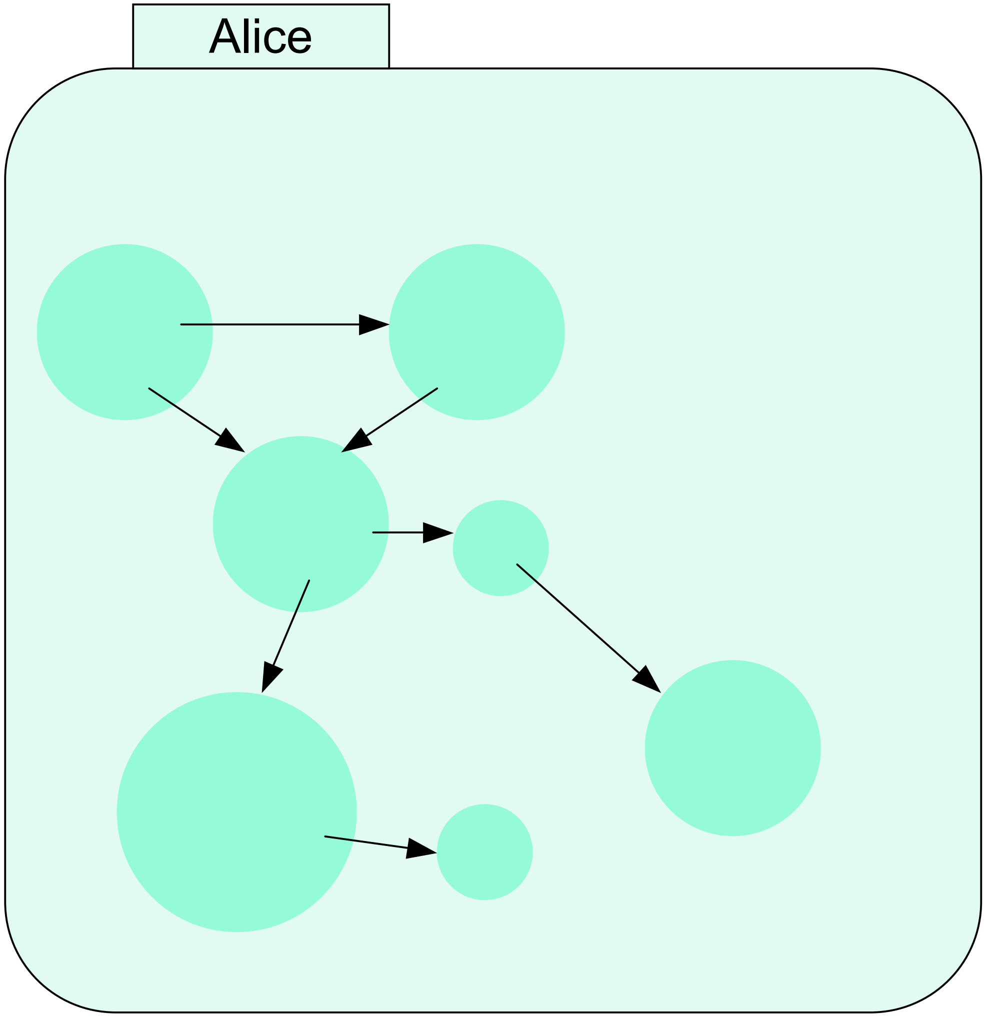

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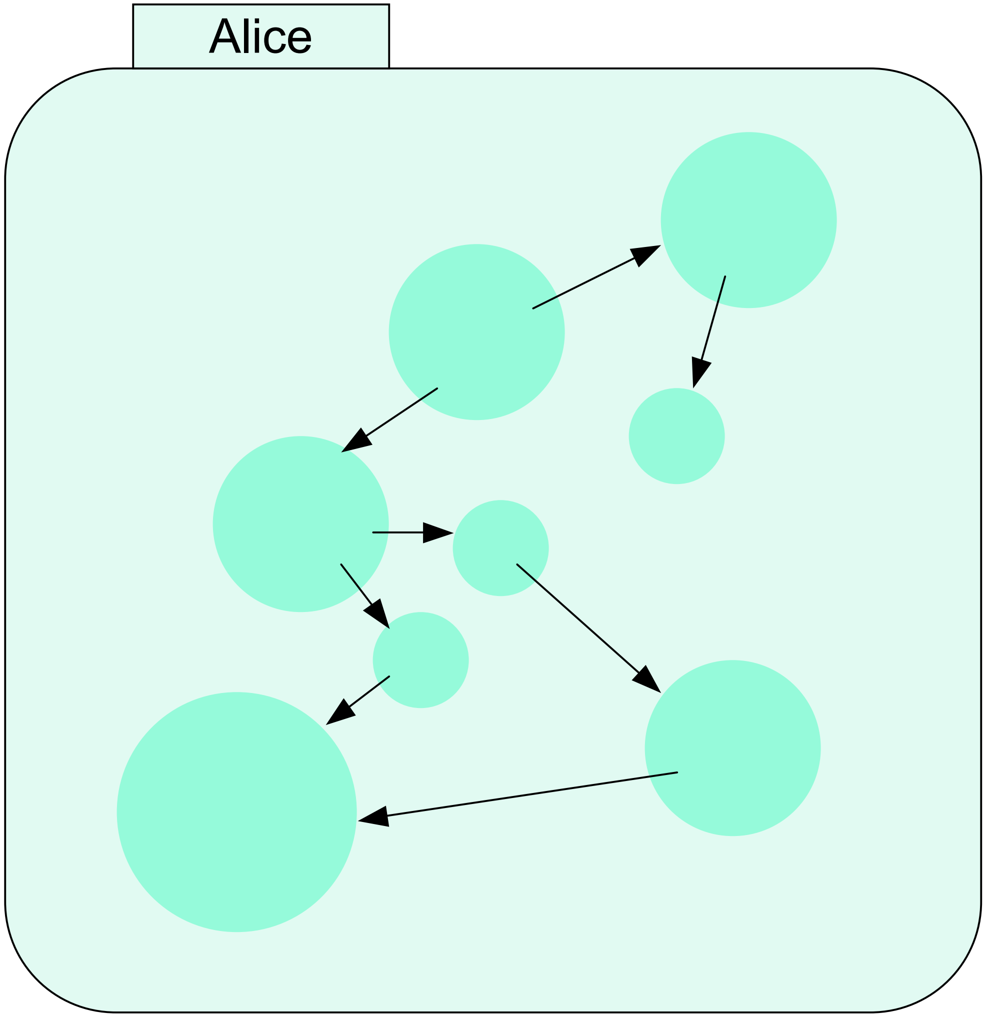

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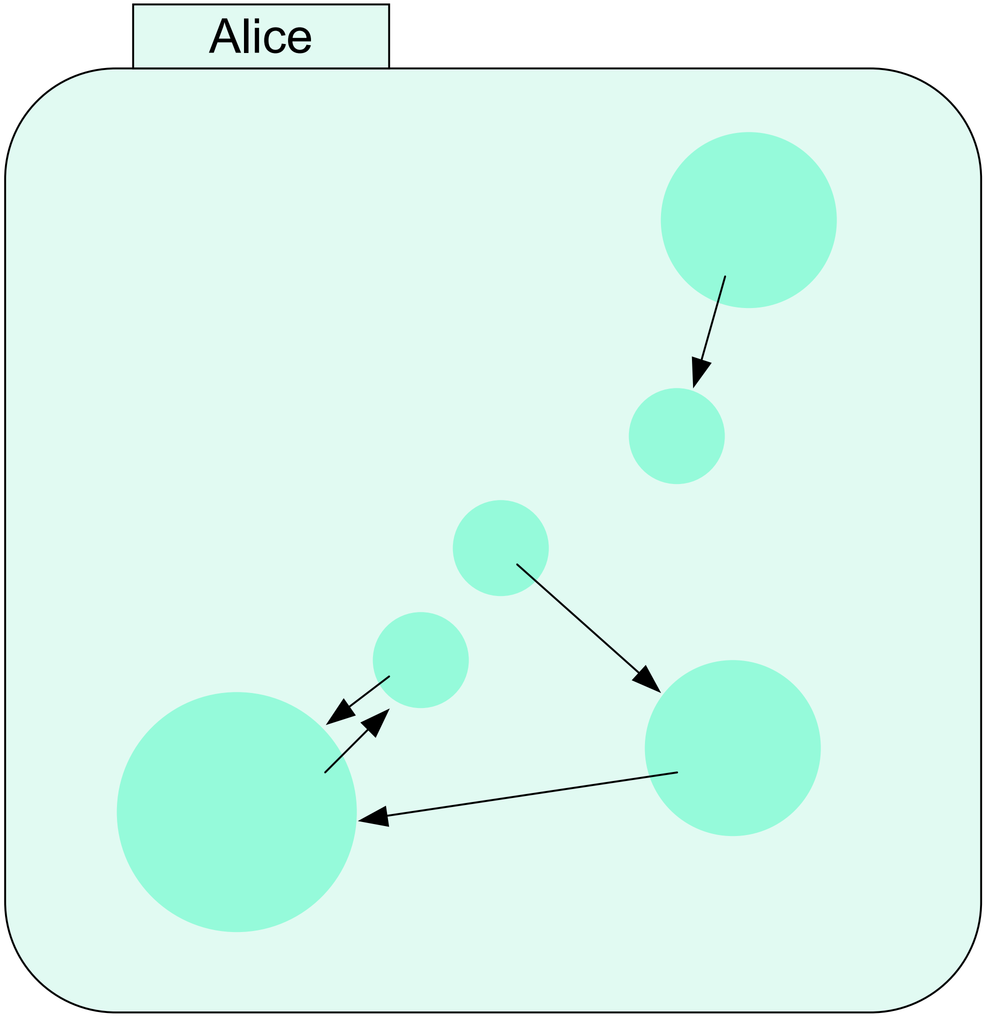
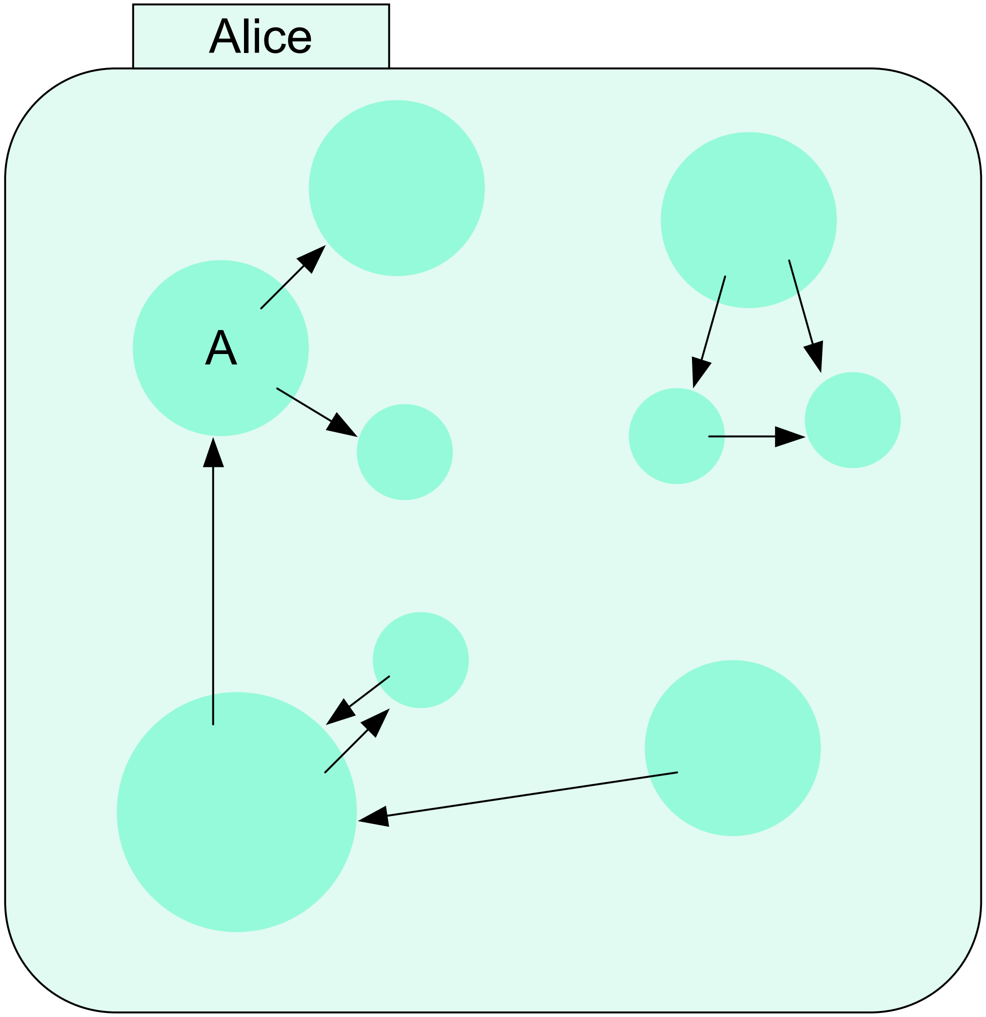


Can’t vet code or actions of each object.



Can’t vet code or actions of each object.

Aggregate into long-lived responsible identity.

Story Needs Four Characters

Alice & Bob

- Old patterns for identity-based control: *identity tunnel*

Alice introduces Bob & Carol

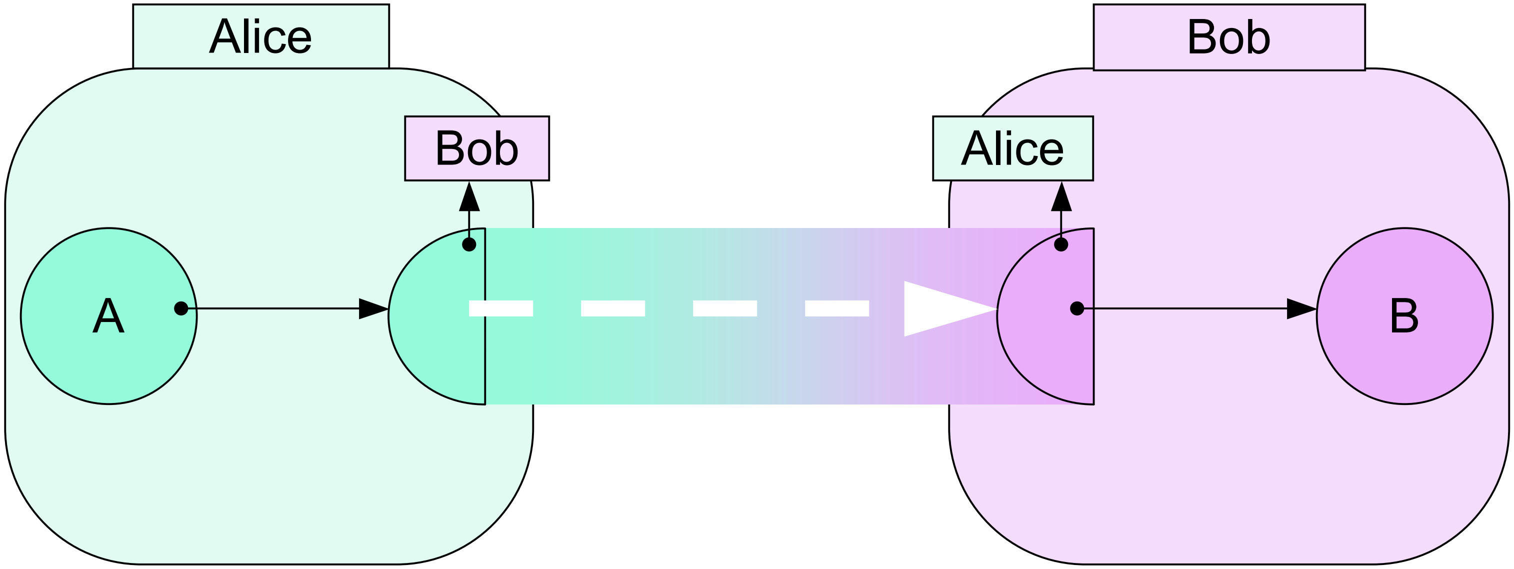
- Builds new relationships from old

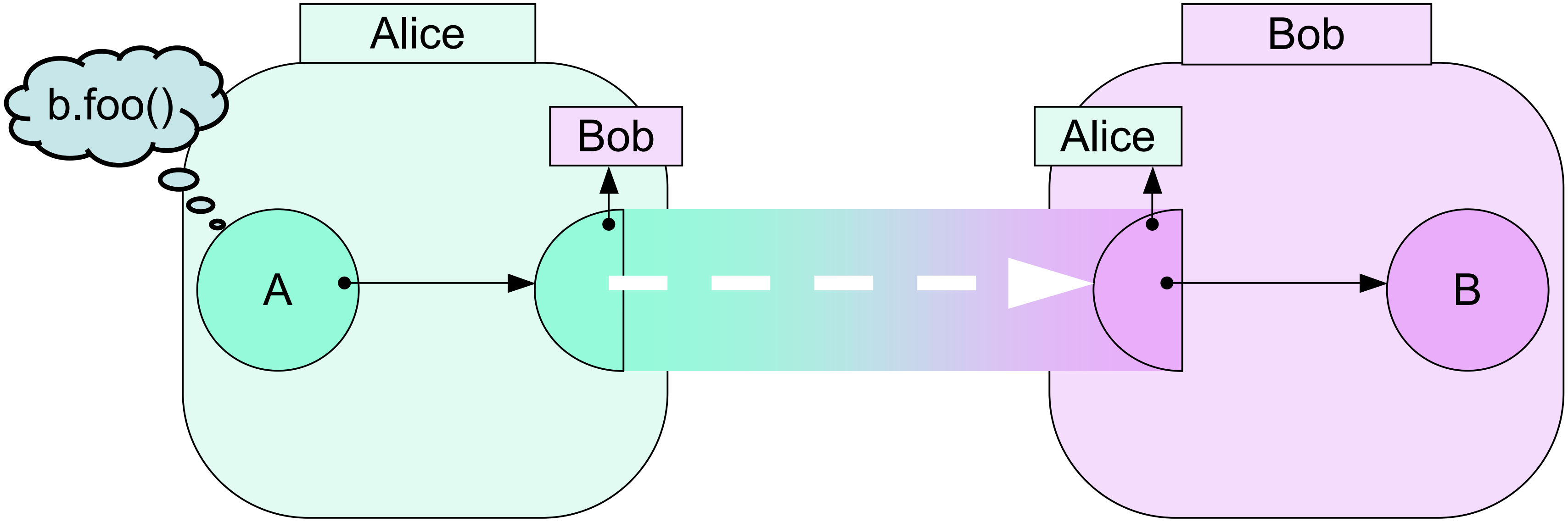
Carol also hears of Bob from Dave

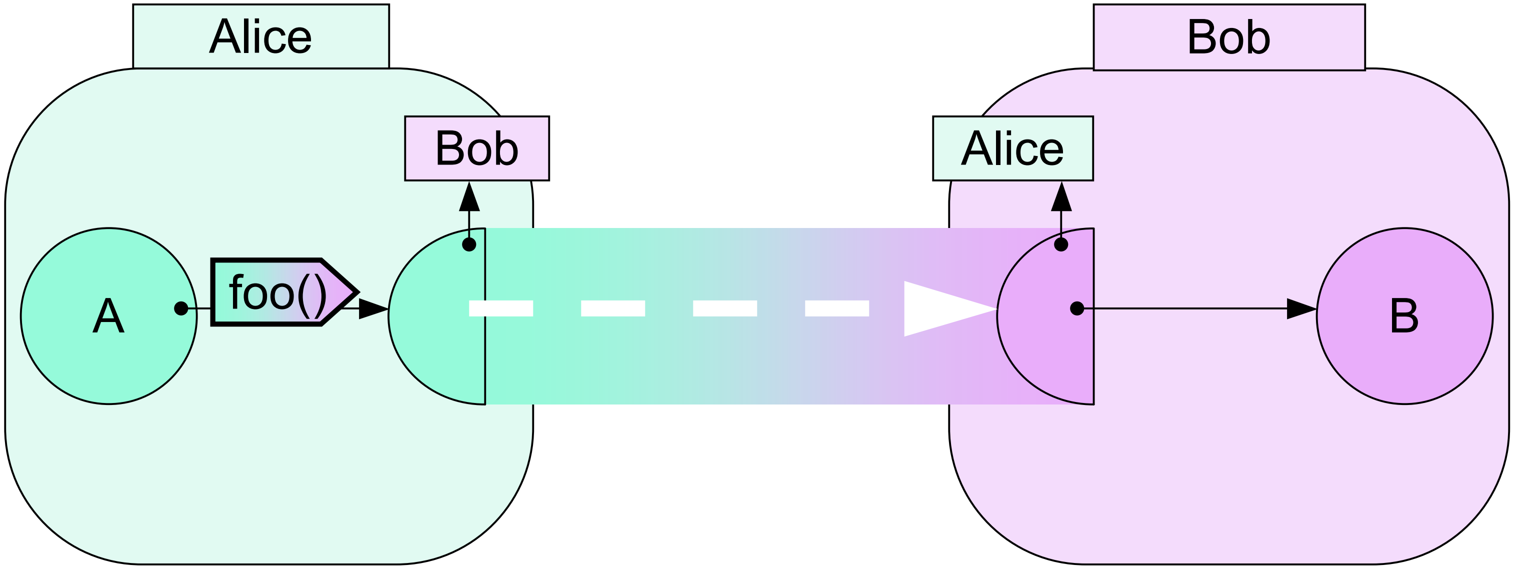
- Corroborates Bob’s independence from Alice

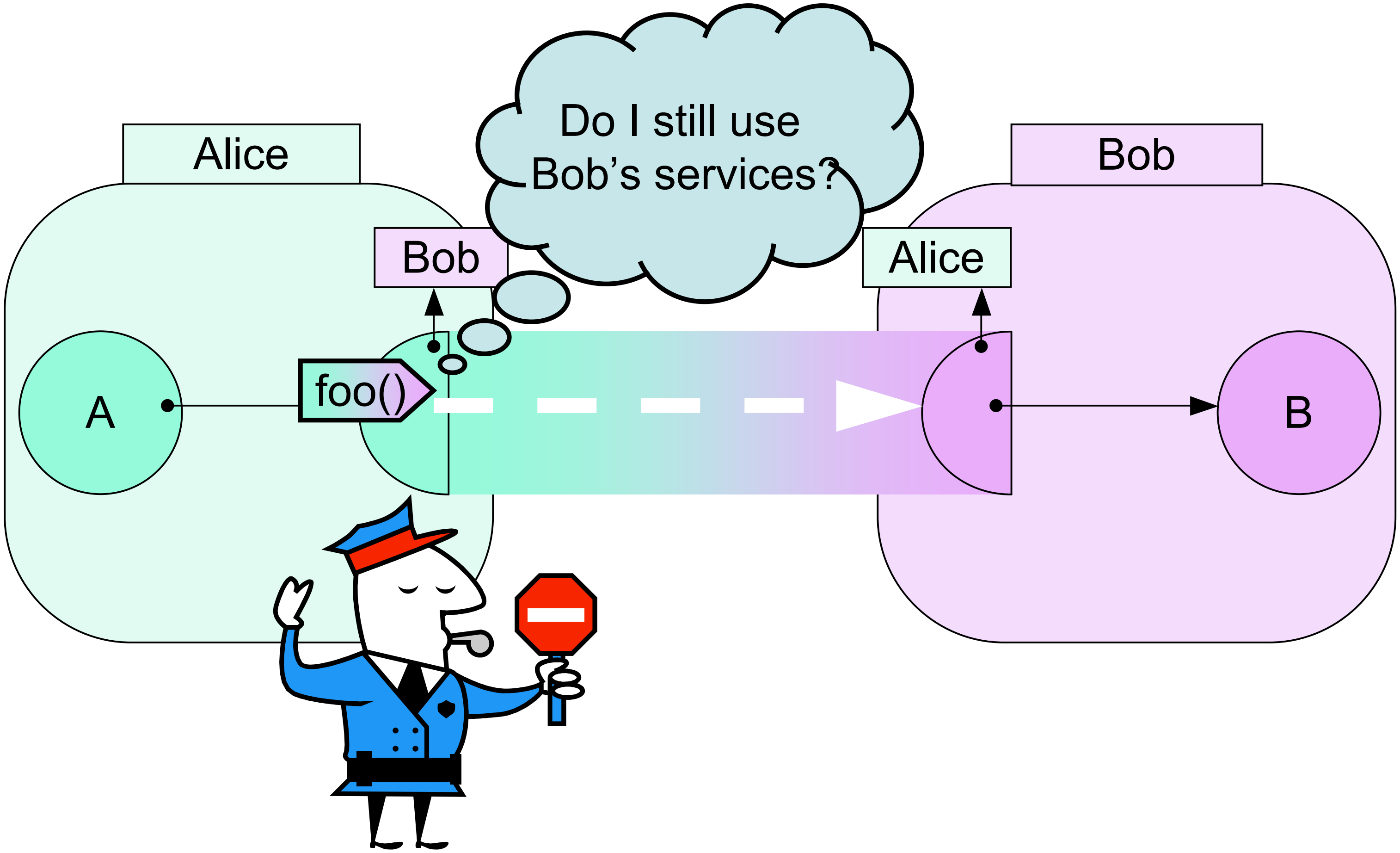
Two-party intermediation

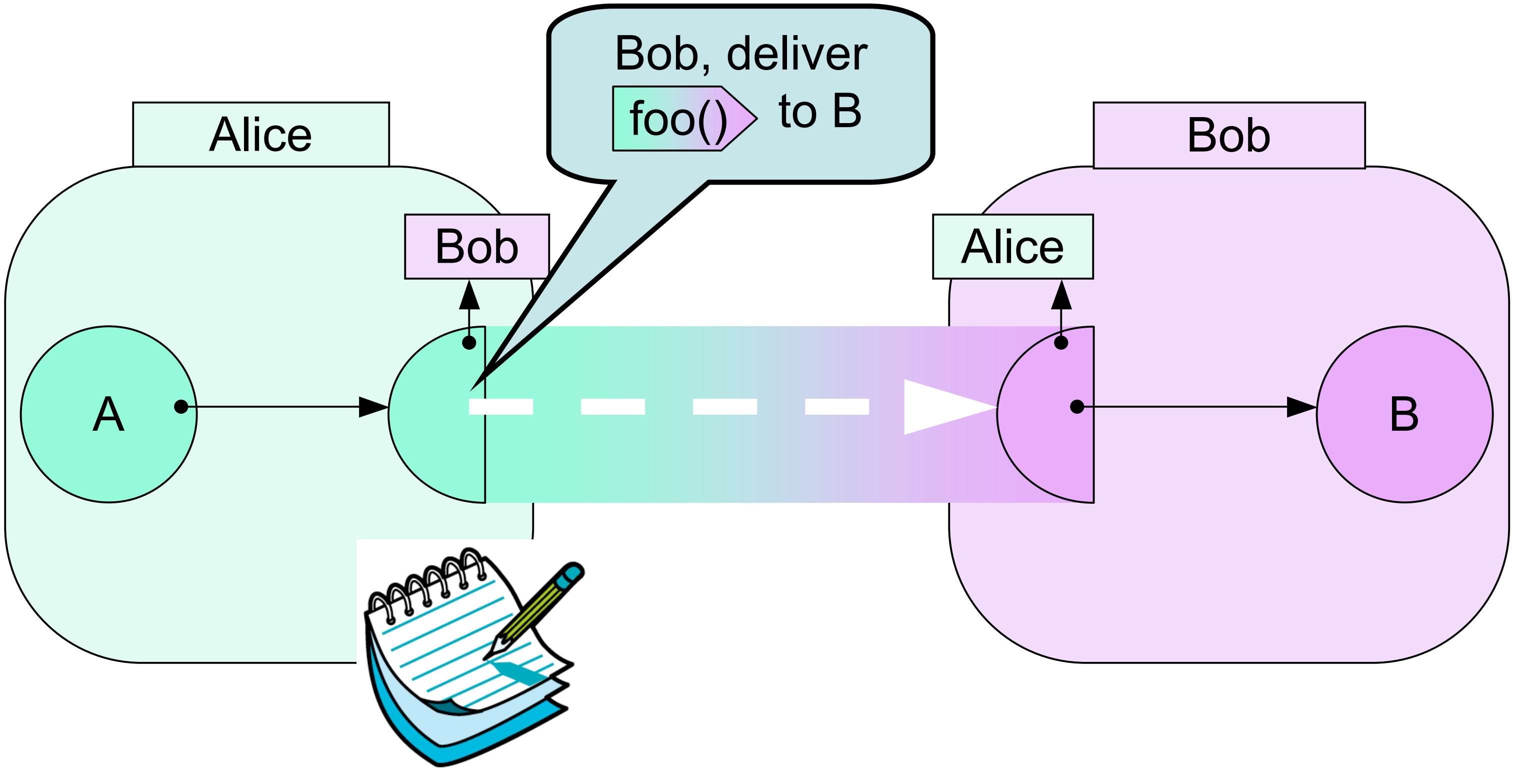
A message travels through an
identity tunnel

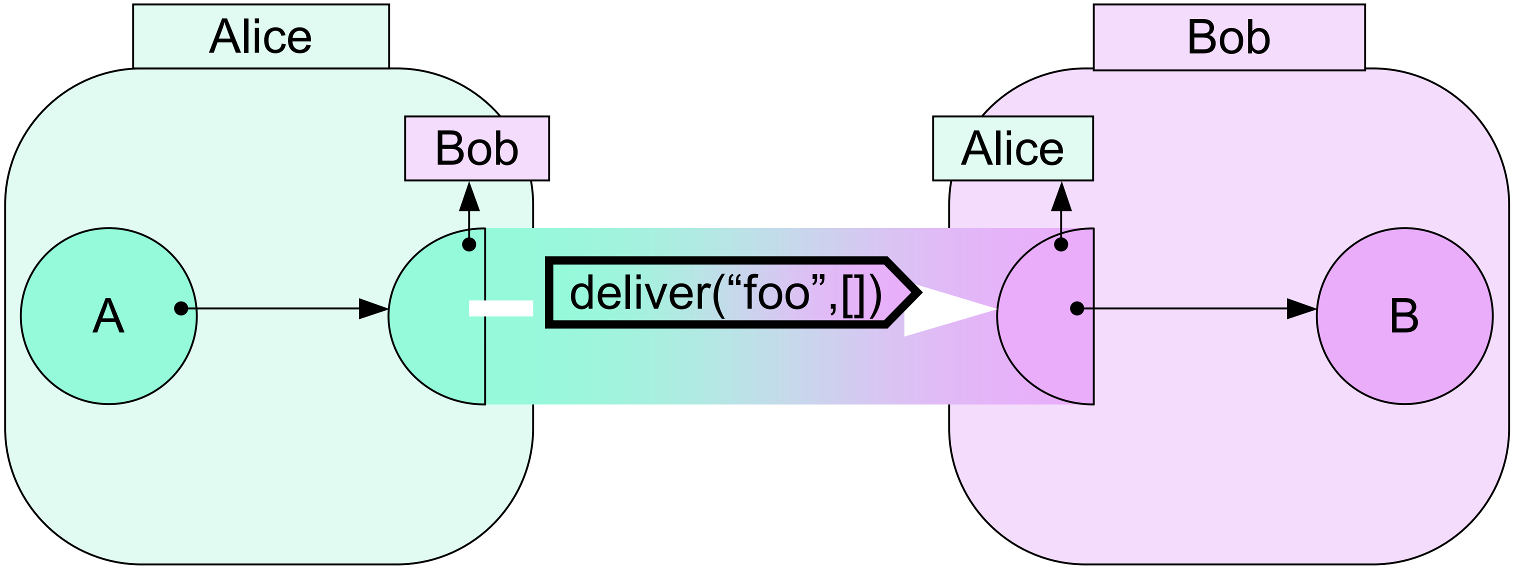

Alice
Bob
A
Bob
Alice
B

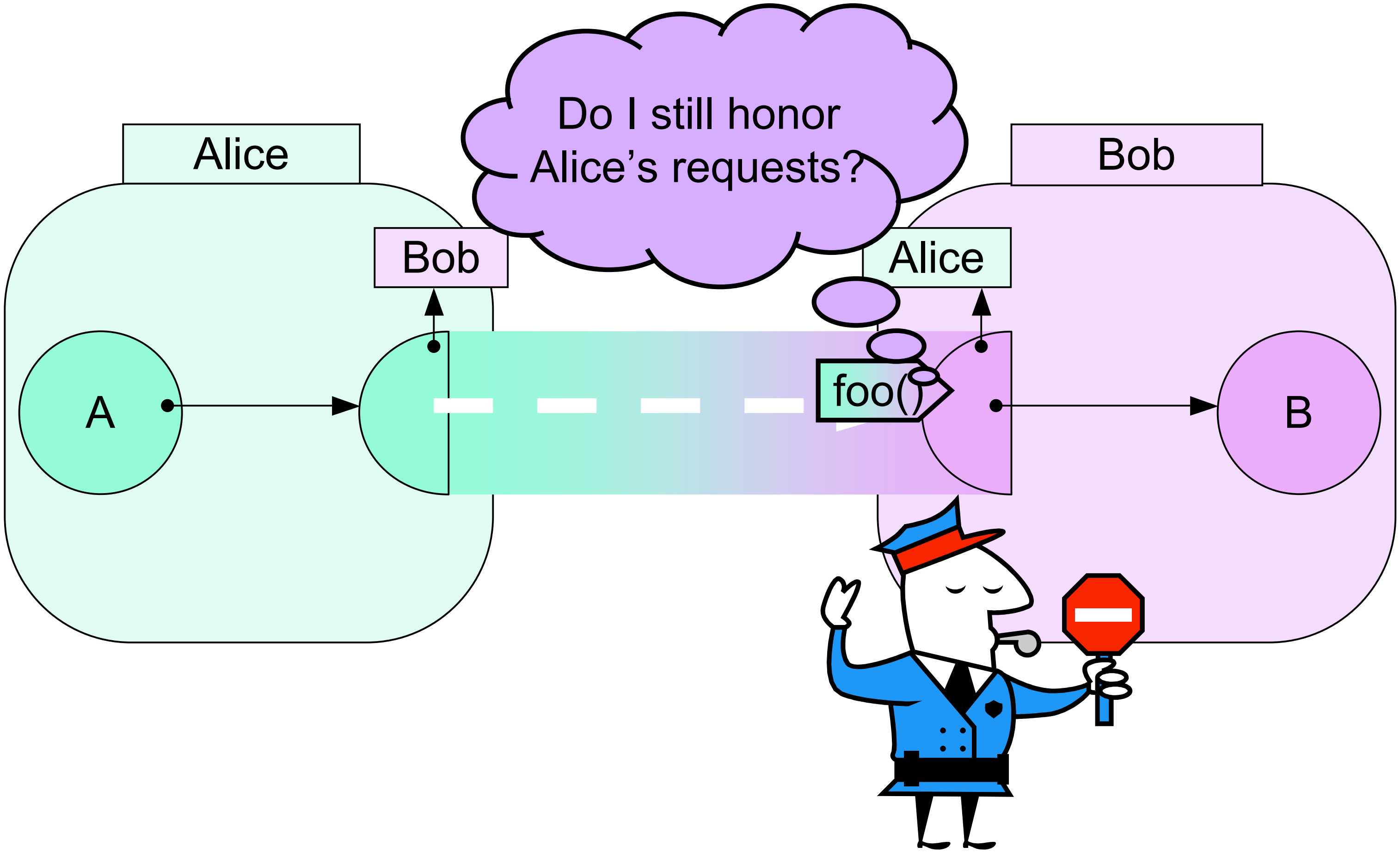

b.foo()
Alice
Bob
A
Bob
Alice
B

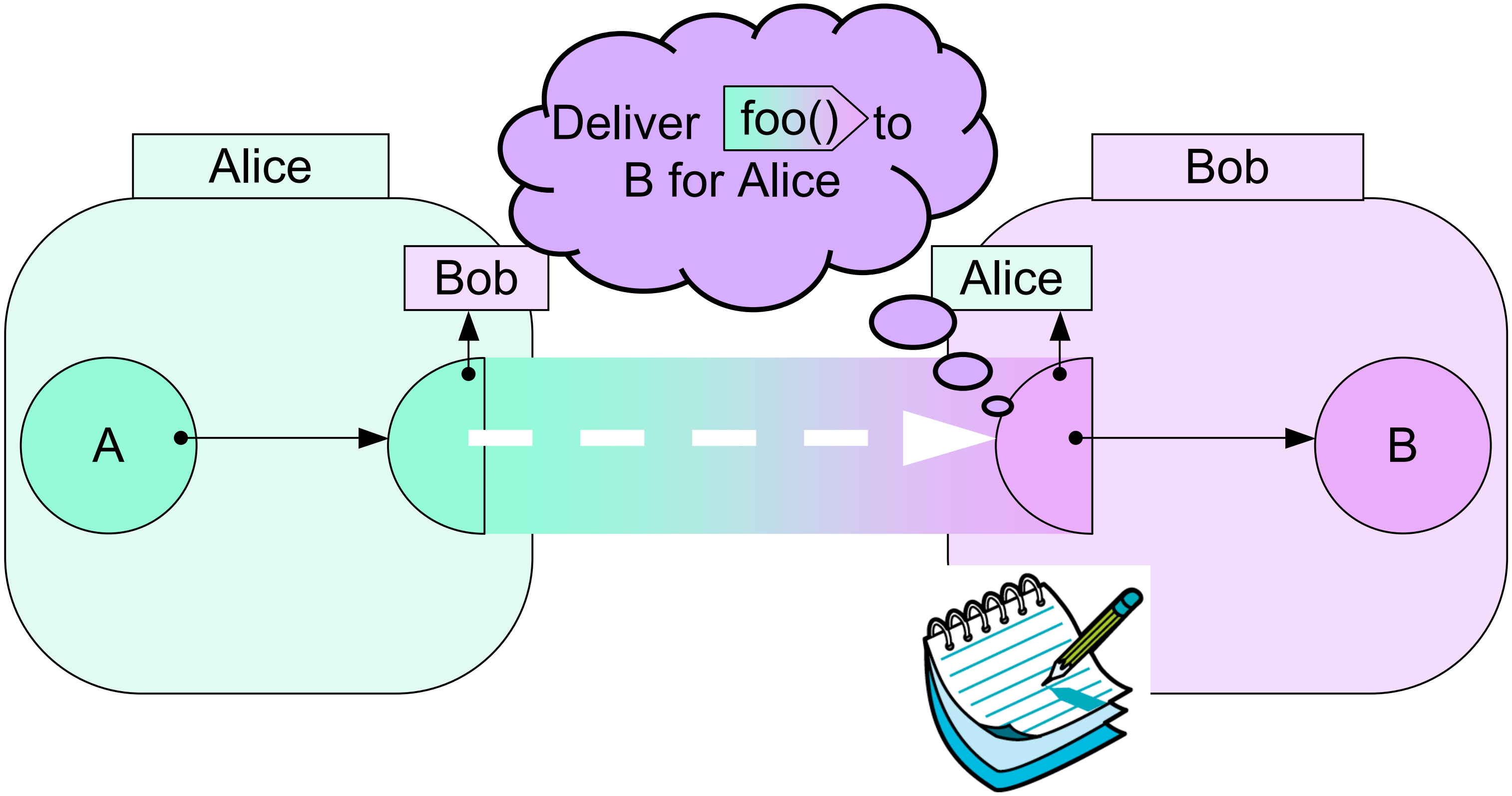

Alice
Bob
Bob
Alice
A
foo()
B

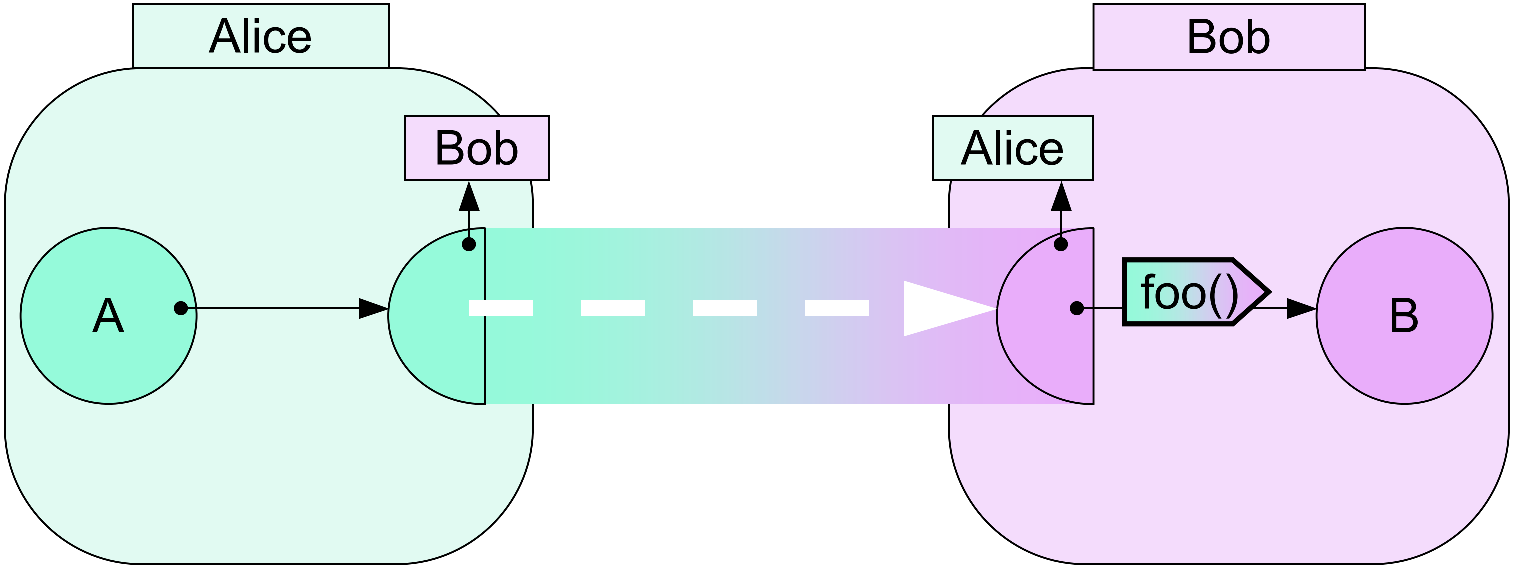

Do I still use
Bob's services?
Alice
Bob
Bob
Alice
A
foo()
B

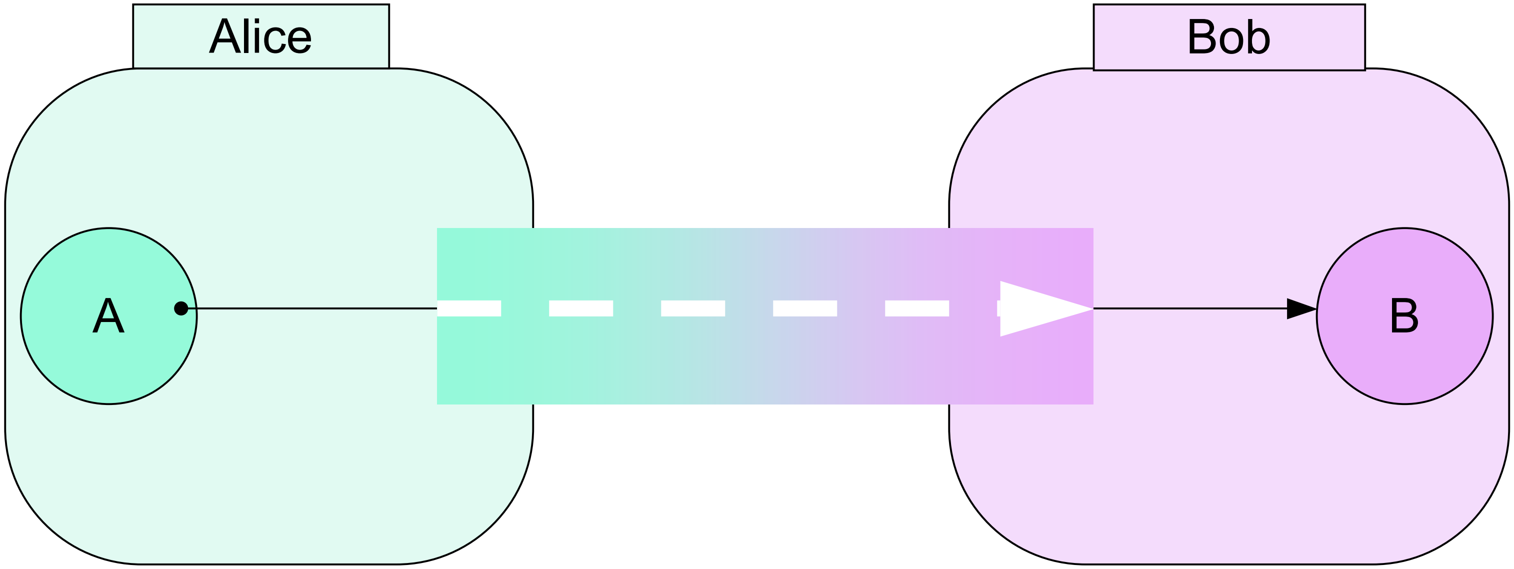

Bob, deliver foo() to B
Alice
Bob
A
Bob
Alice
B


Alice
Bob
Bob
Alice
A
deliver("foo",[])
B


Do I still honor
Alice's requests?
Alice
Bob
Bob
Alice
A
foo()
B

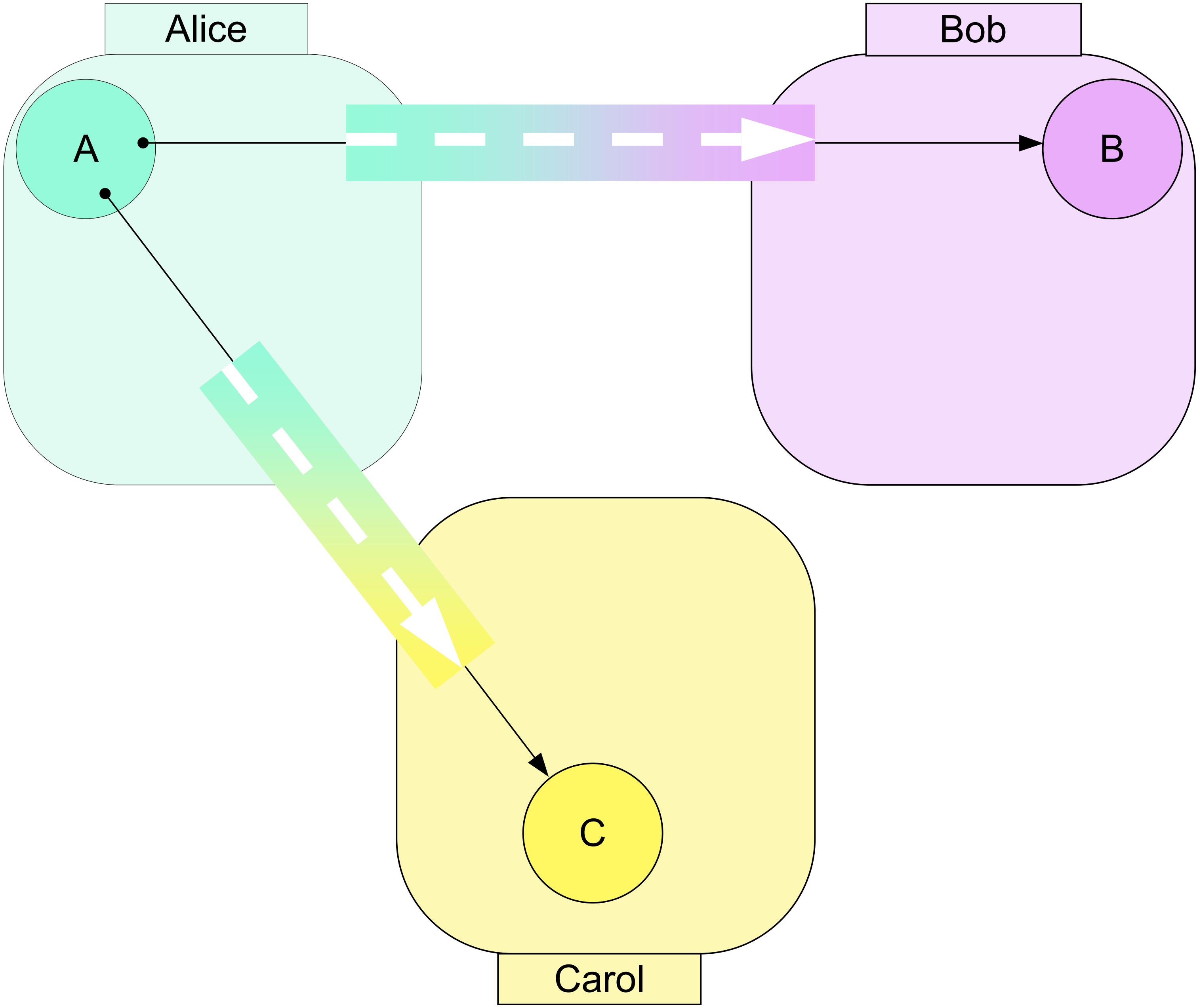

Deliver foo() to
B for Alice
Alice
Bob
Bob
Alice
A
B

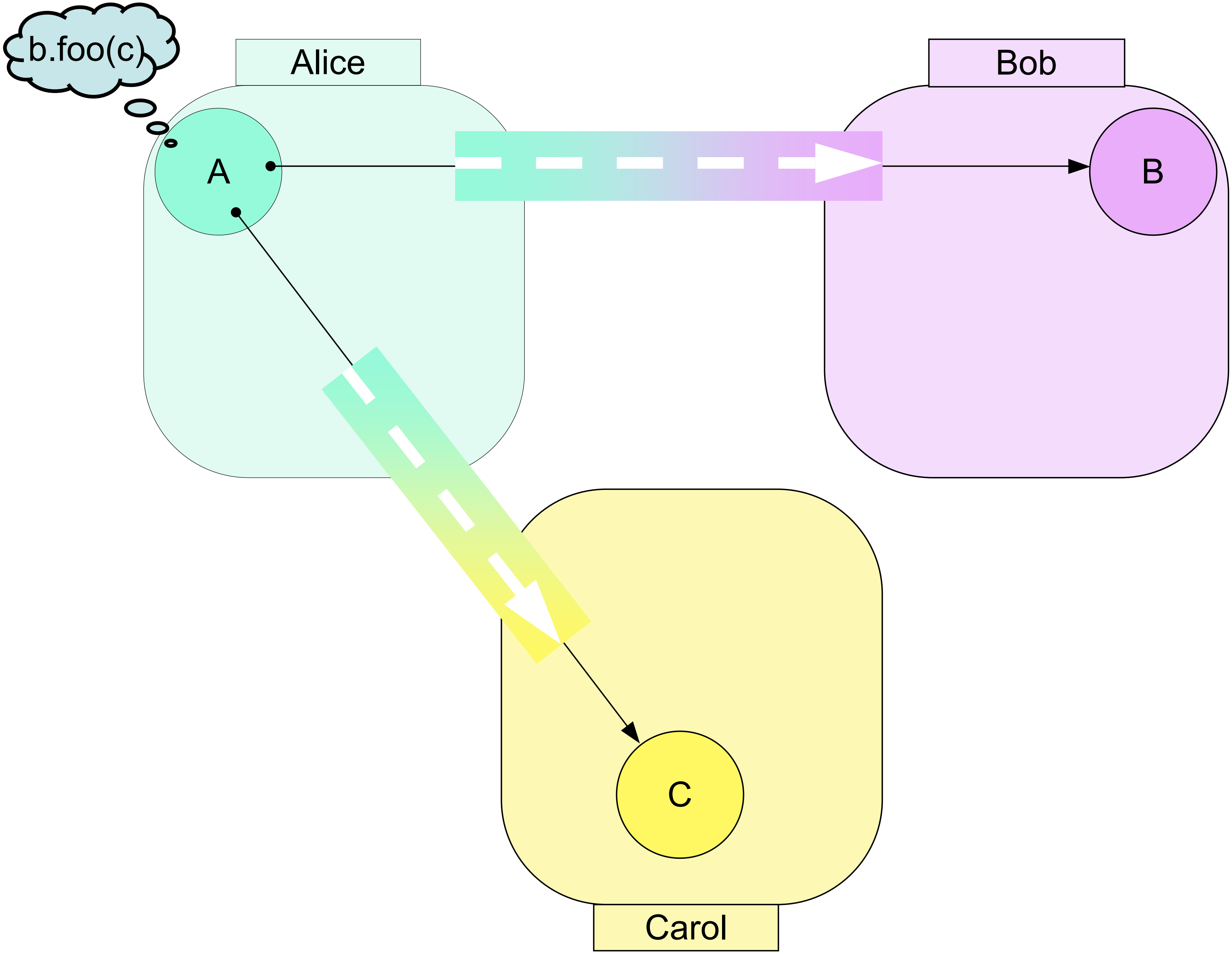

Alice
Bob
Bob
Alice
A
foo()
B

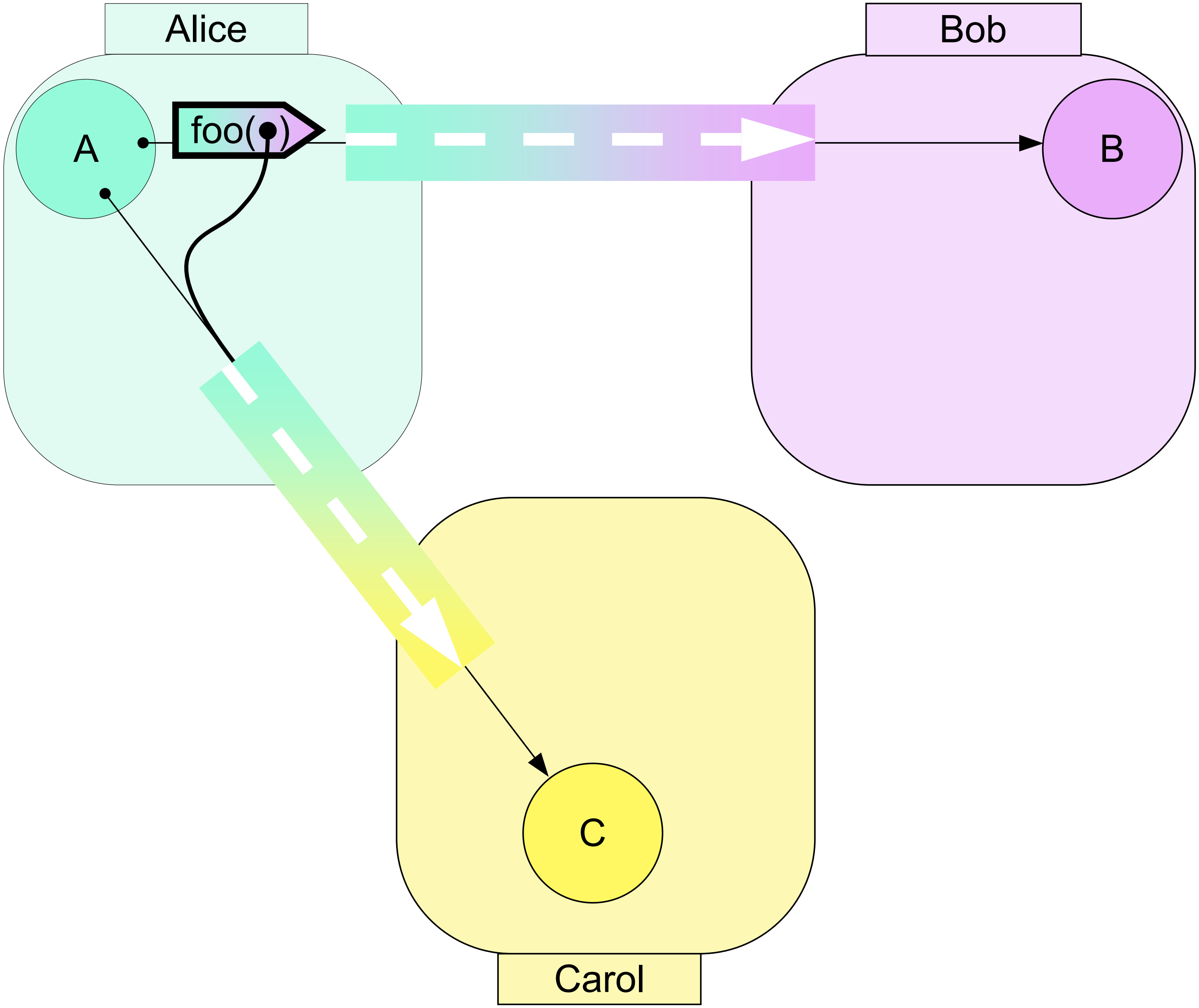

Alice
Bob
A
B

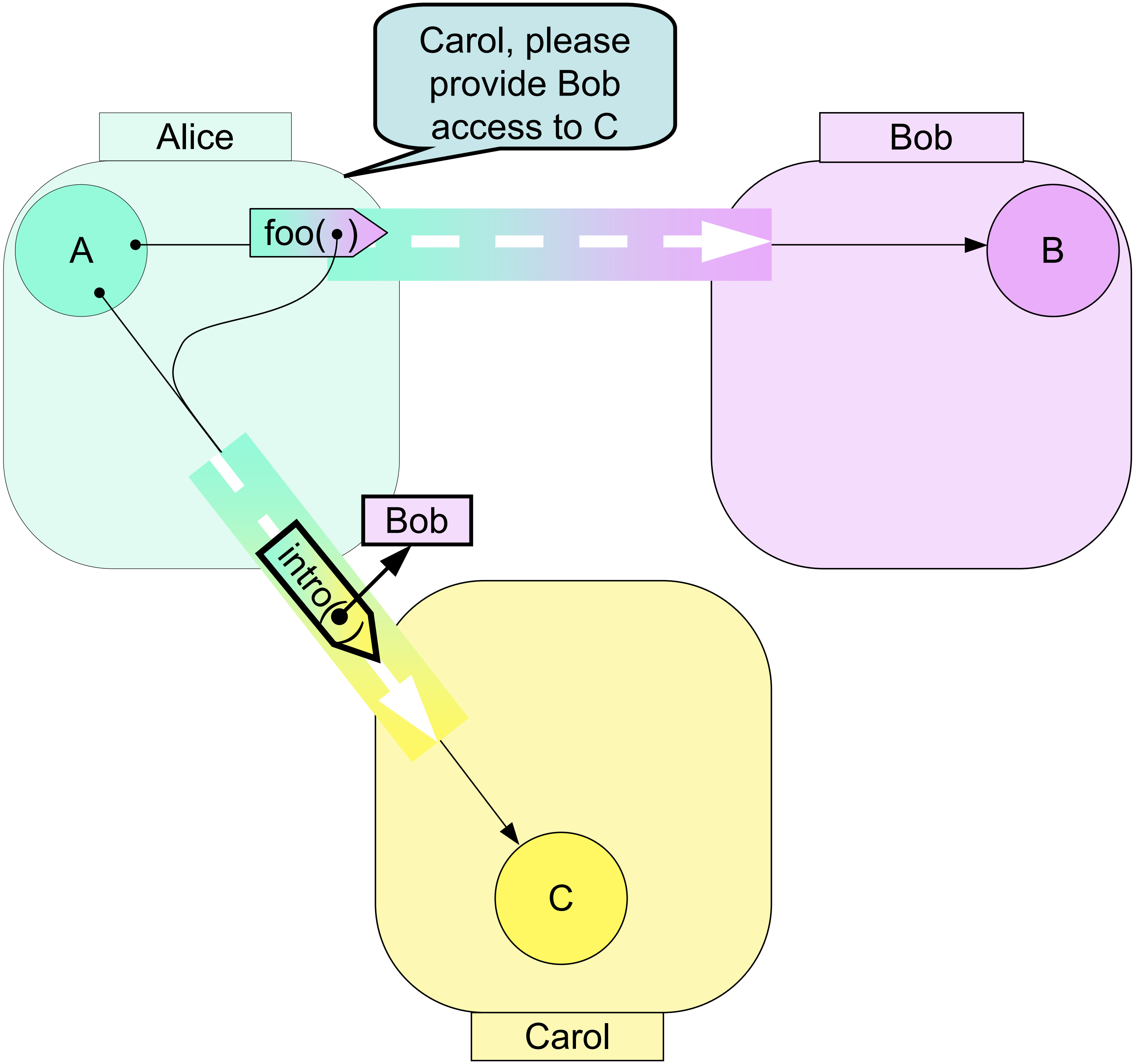
Three-party intermediation

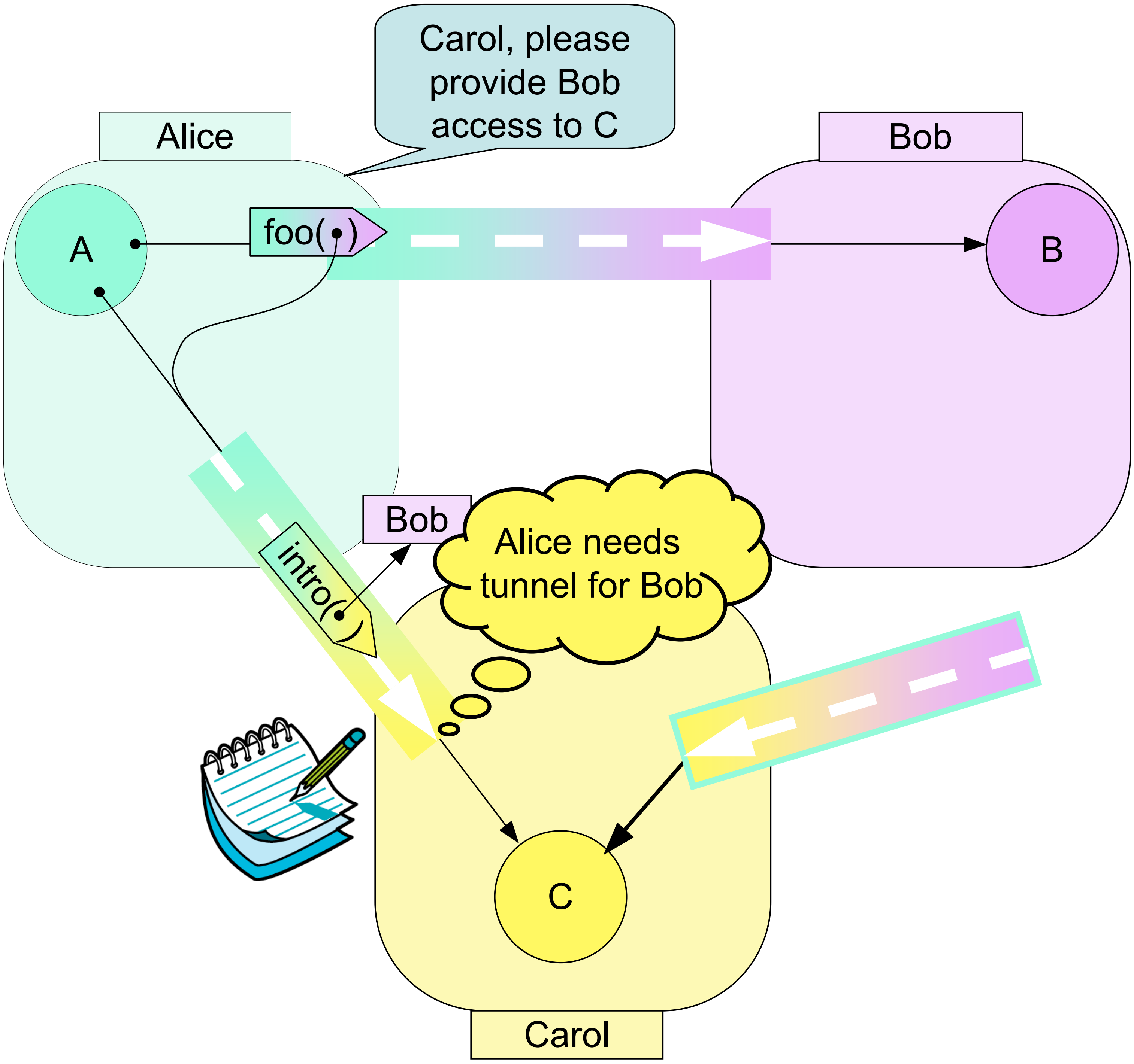
Build new relationships from old

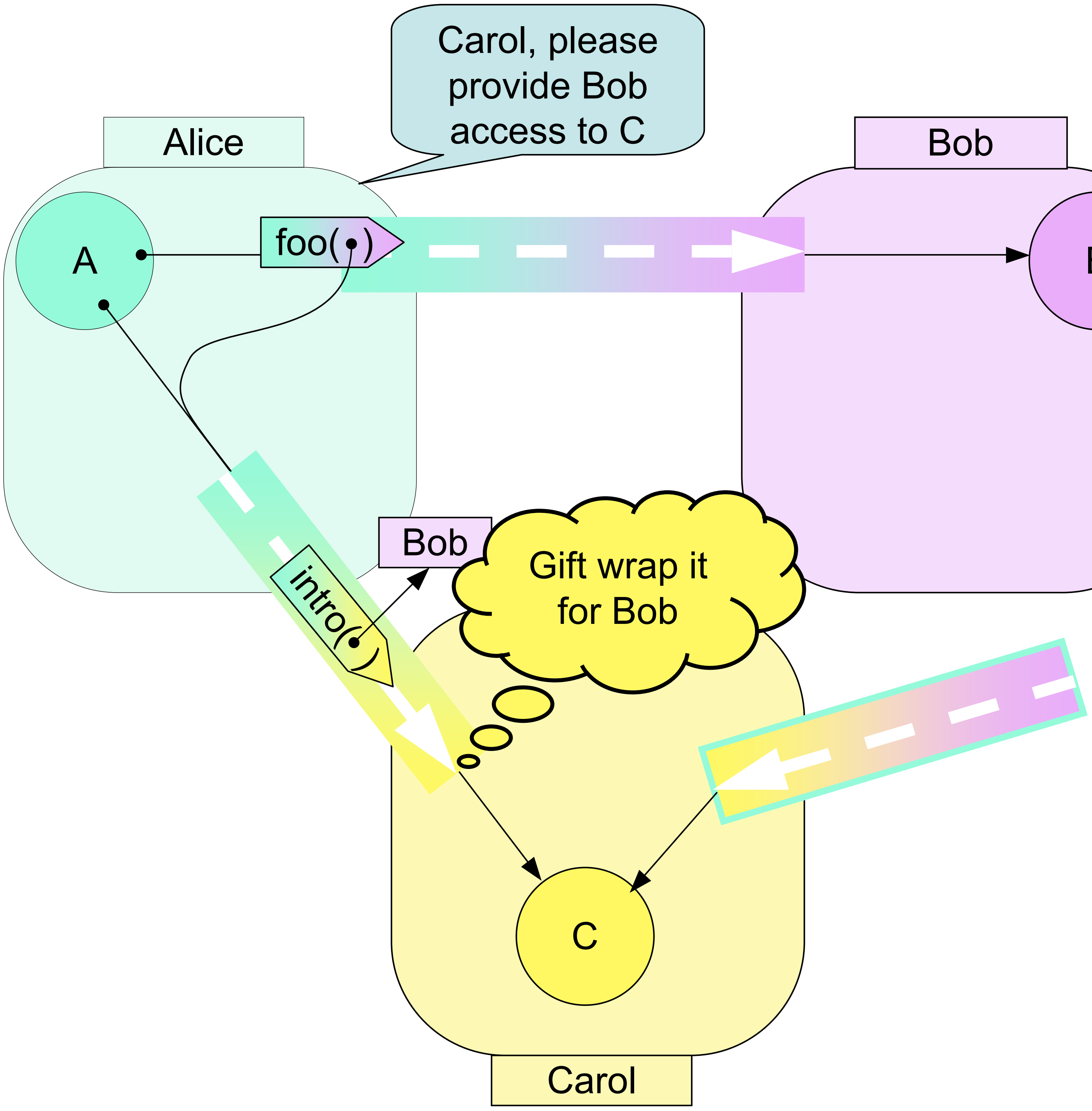

Alice
Bob
A
B
C
Carol

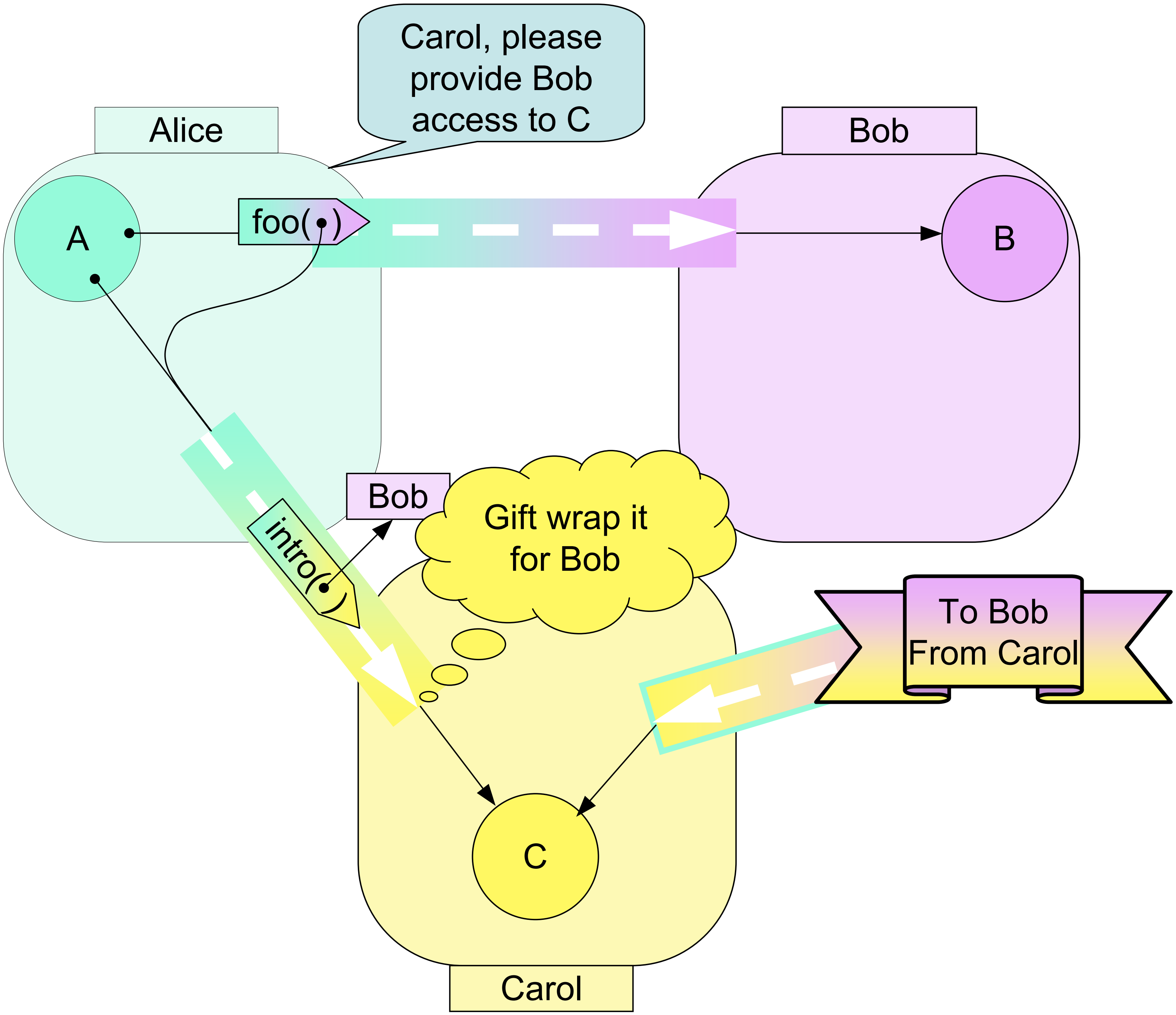

b.foo(c)
Alice
Bob
A
B
C
Carol

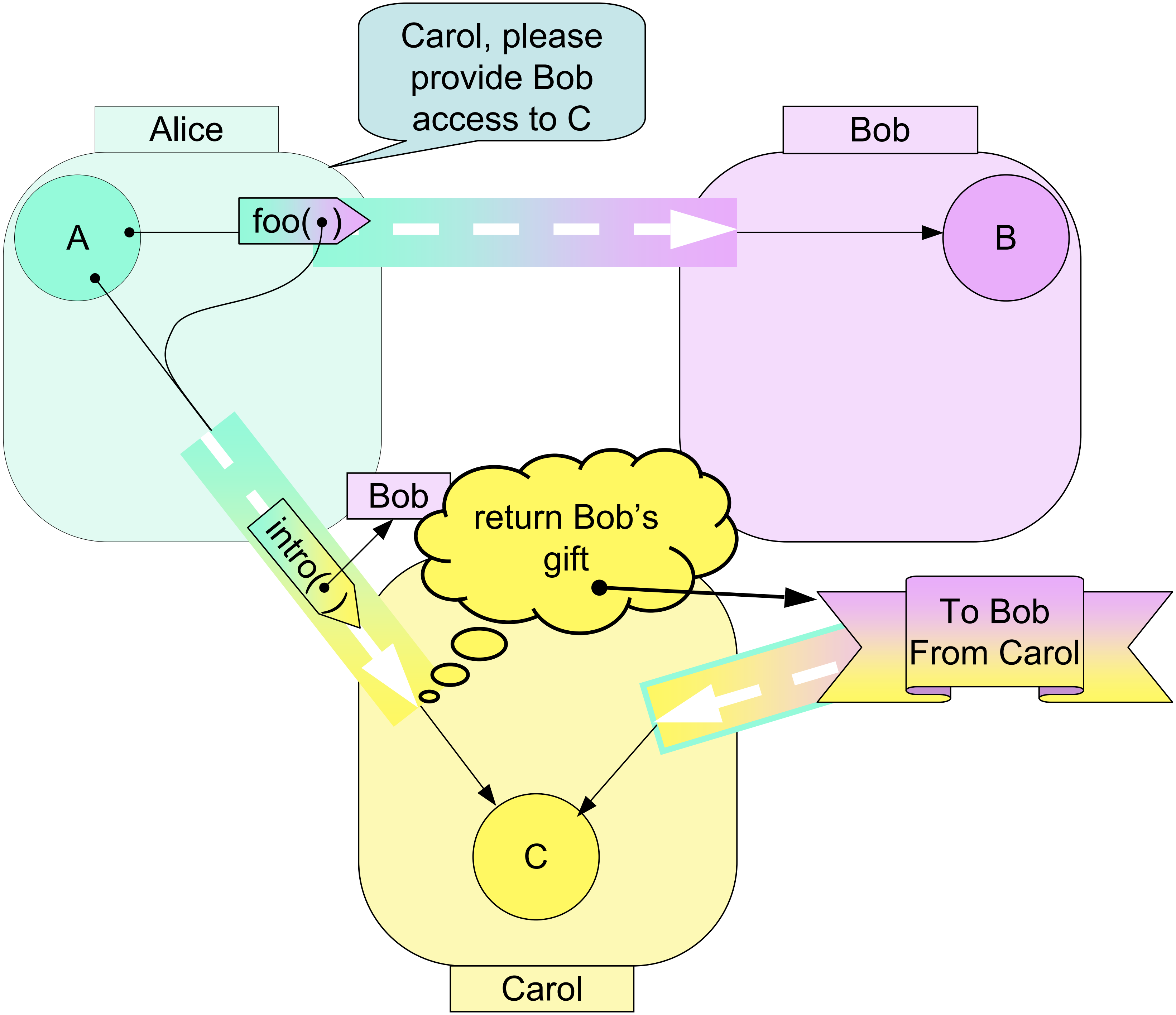

Alice
Bob
A
foo(●)
B
C
Carol

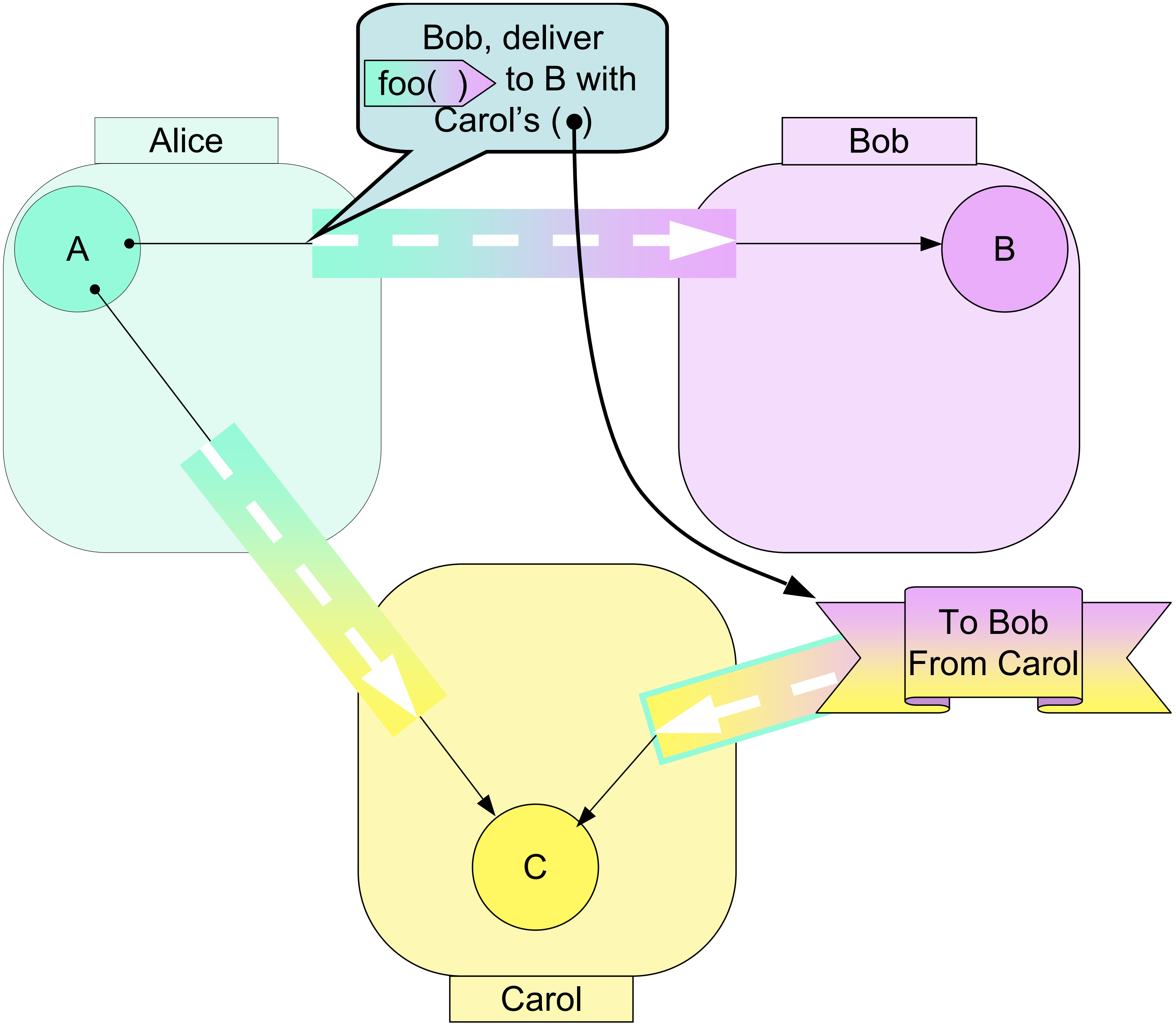

Carol, please provide Bob access to C
Alice
Bob
A
foo( )
B
intro( )
Bob
C
Carol

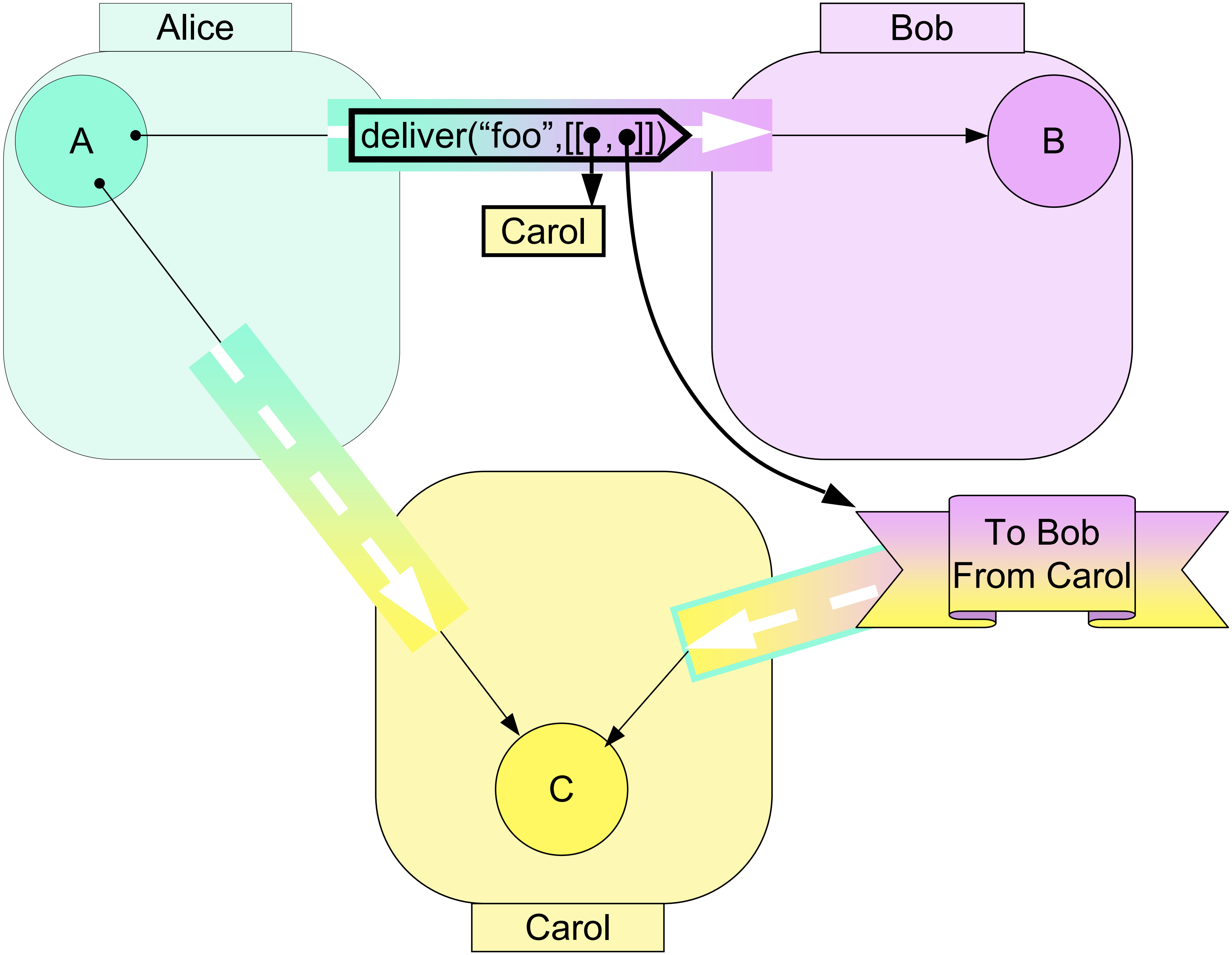

Carol, please provide Bob access to C
Alice
Bob
A
foo( )
B
Bob
Alice needs tunnel for Bob
intro( )
C
Carol

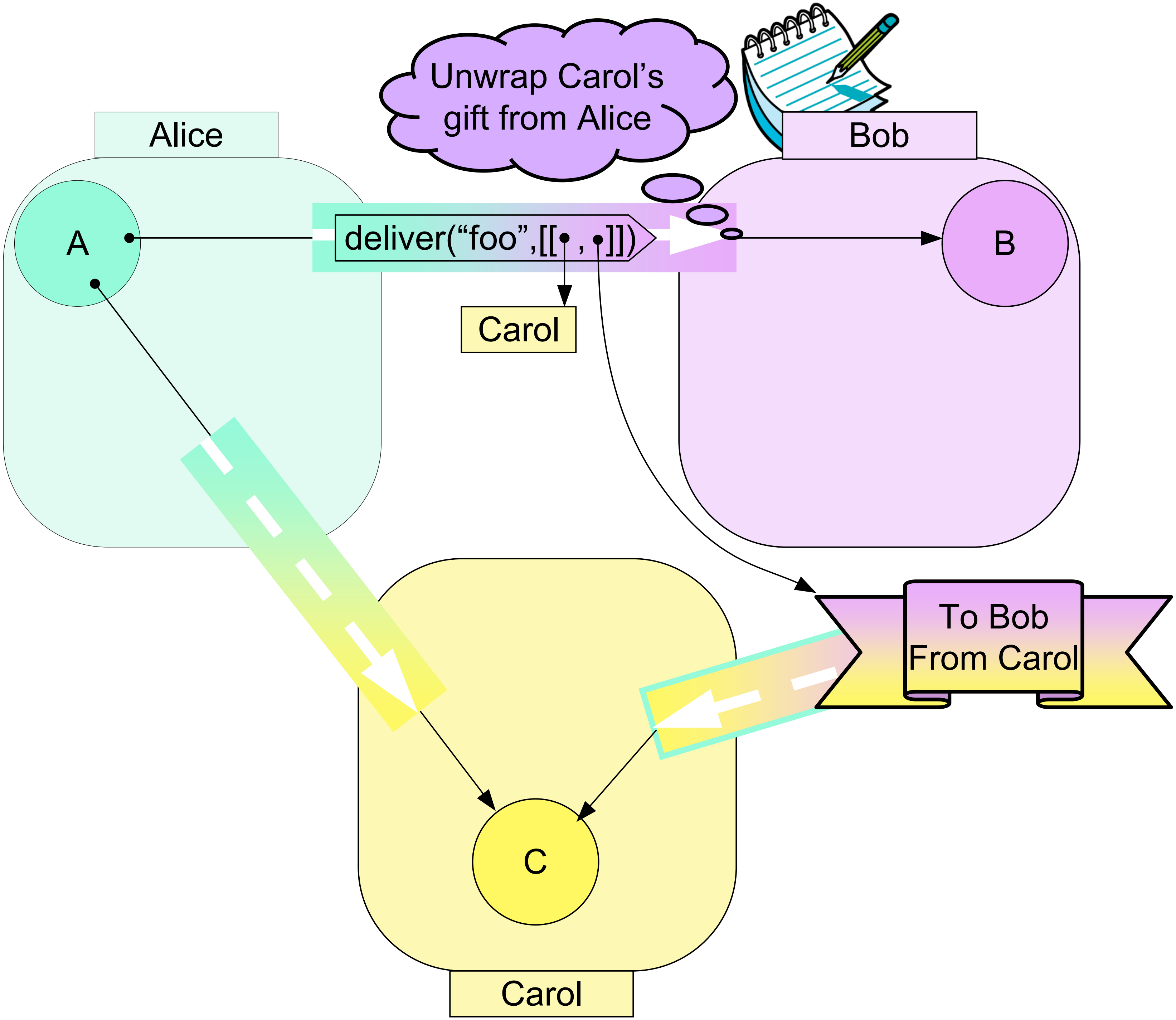

Carol, please provide Bob access to C
Alice
Bob
A
foo( )
B
Bob
Gift wrap it for Bob
intro( )
C
Carol

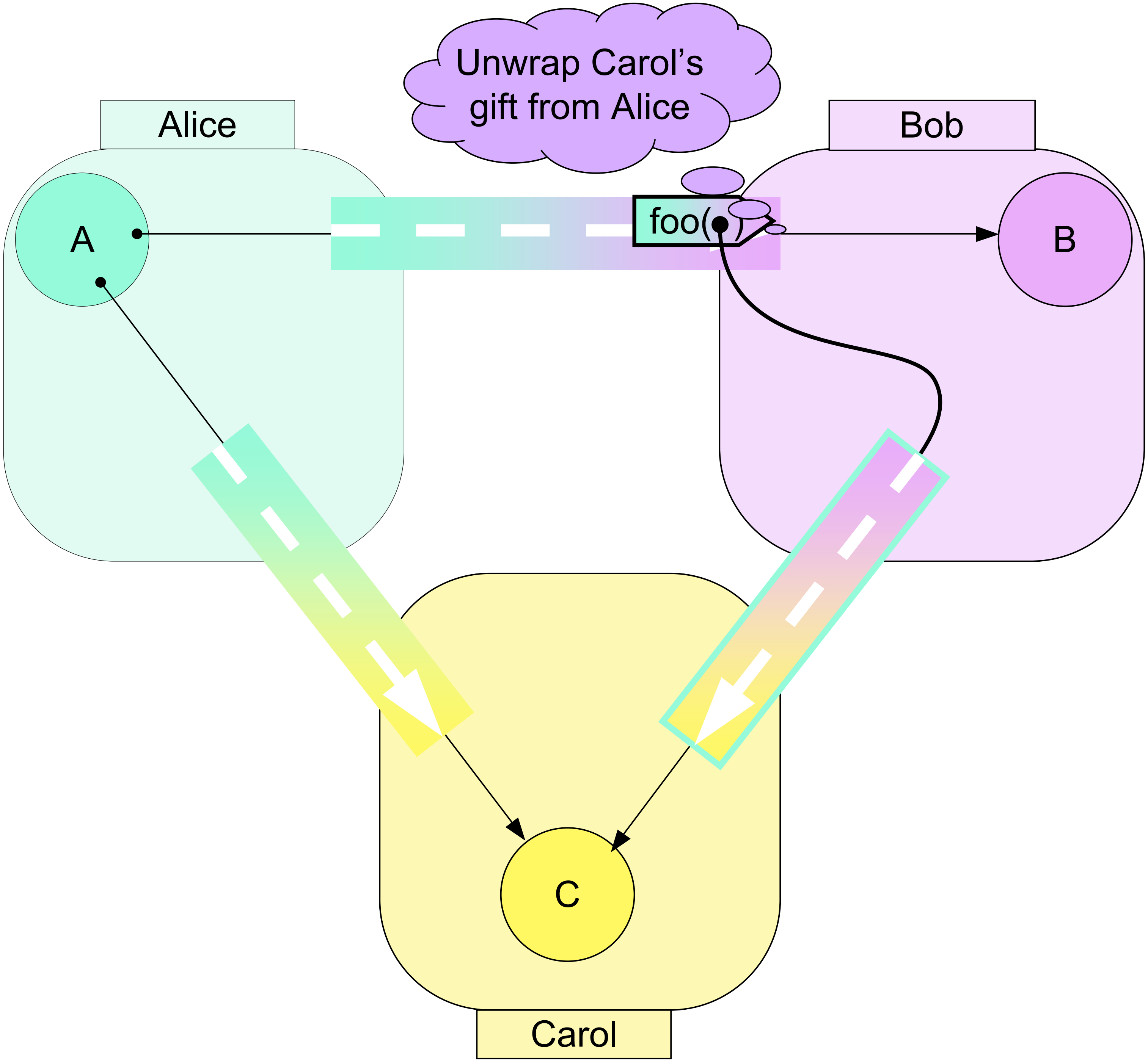

Carol, please provide Bob access to C
Alice
Bob
A
foo( )
B
Bob
intro( )
Gift wrap it for Bob
To Bob From Carol
C
Carol

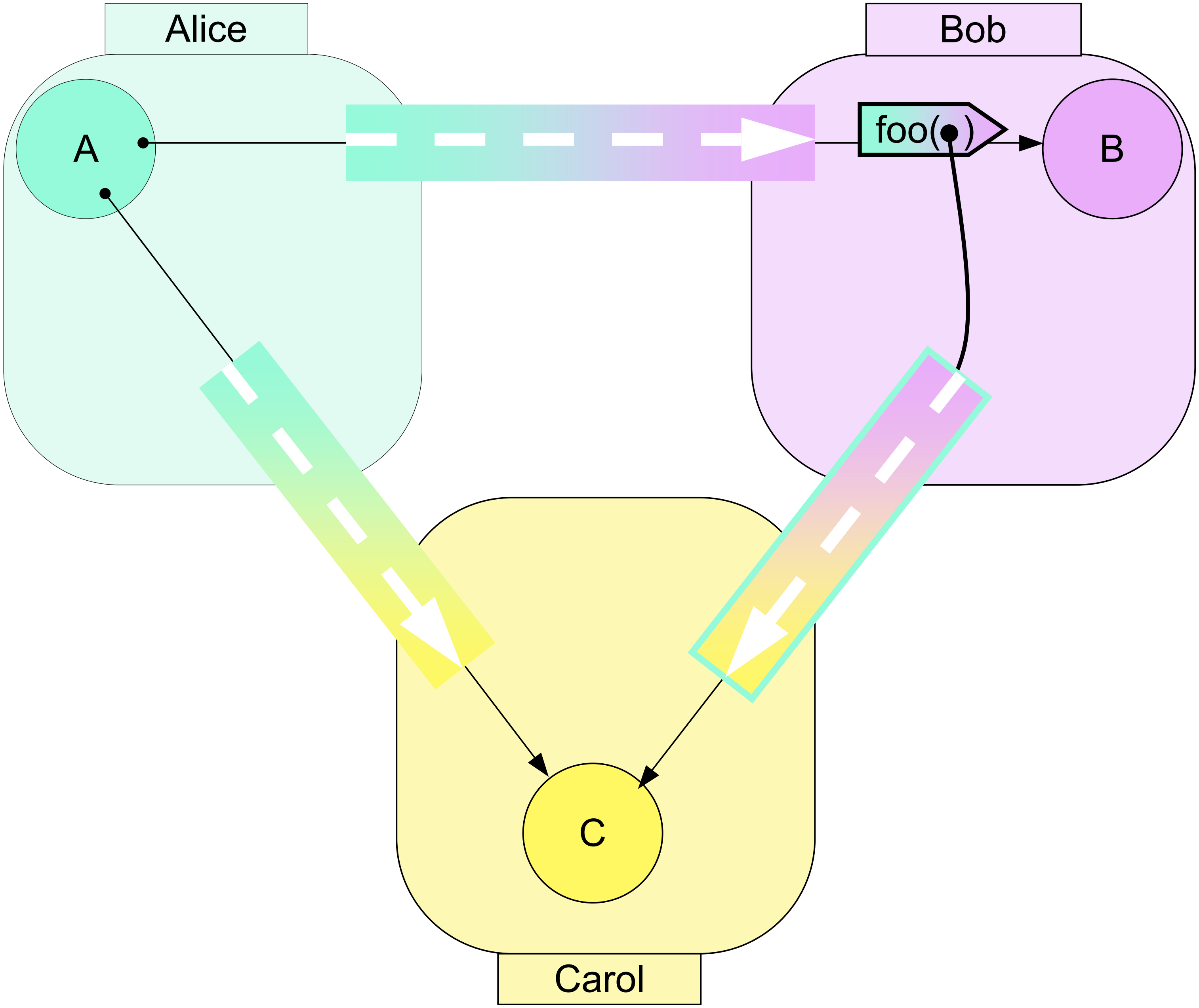

Carol, please provide Bob access to C
Alice
Bob
A
foo( )
B
Bob
return Bob's gift
intro( )
To Bob From Carol
C
Carol

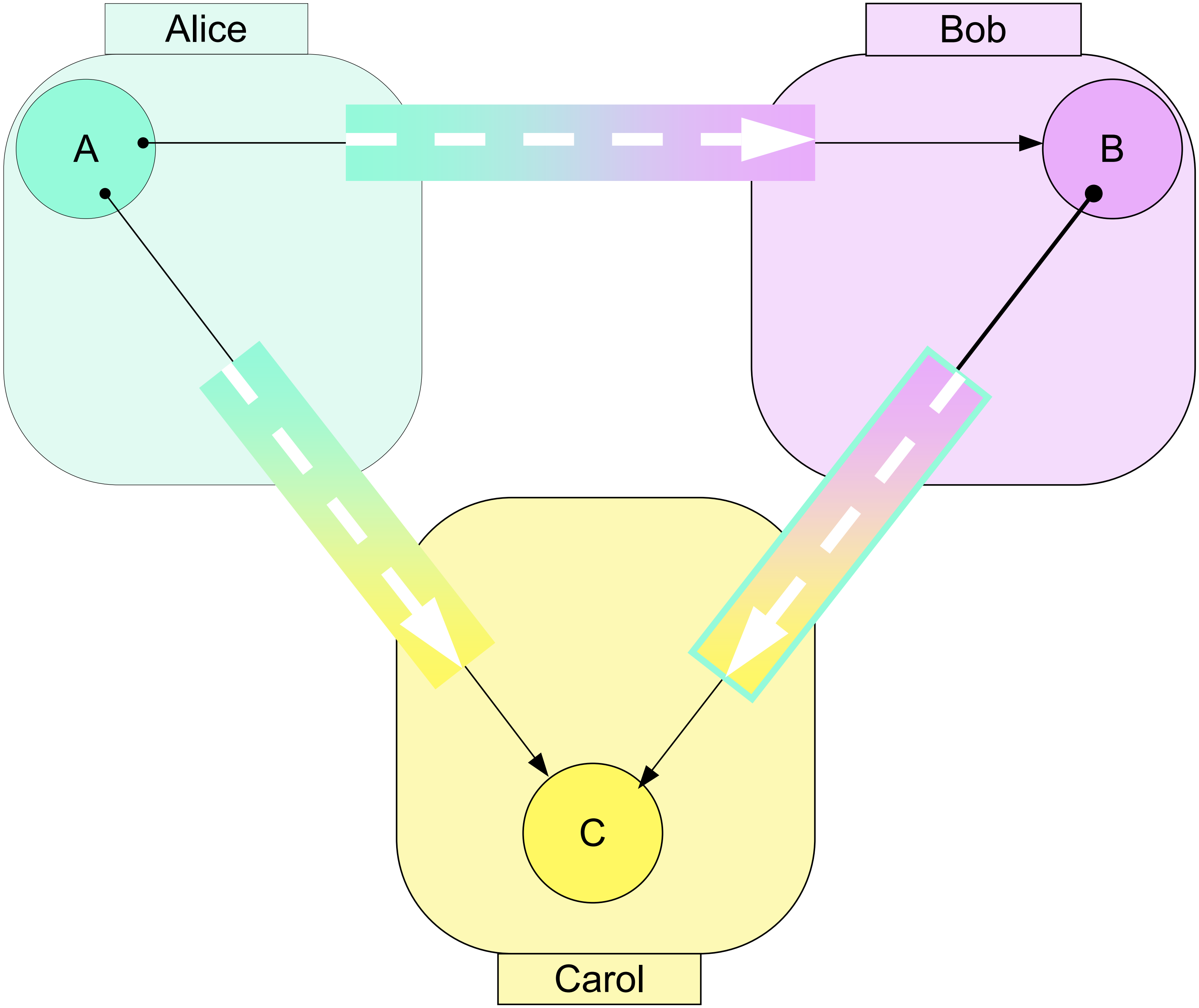

Bob, deliver
foo( ) to B with
Carol's ( )
Alice
A
Bob
B
To Bob
From Carol
C
Carol

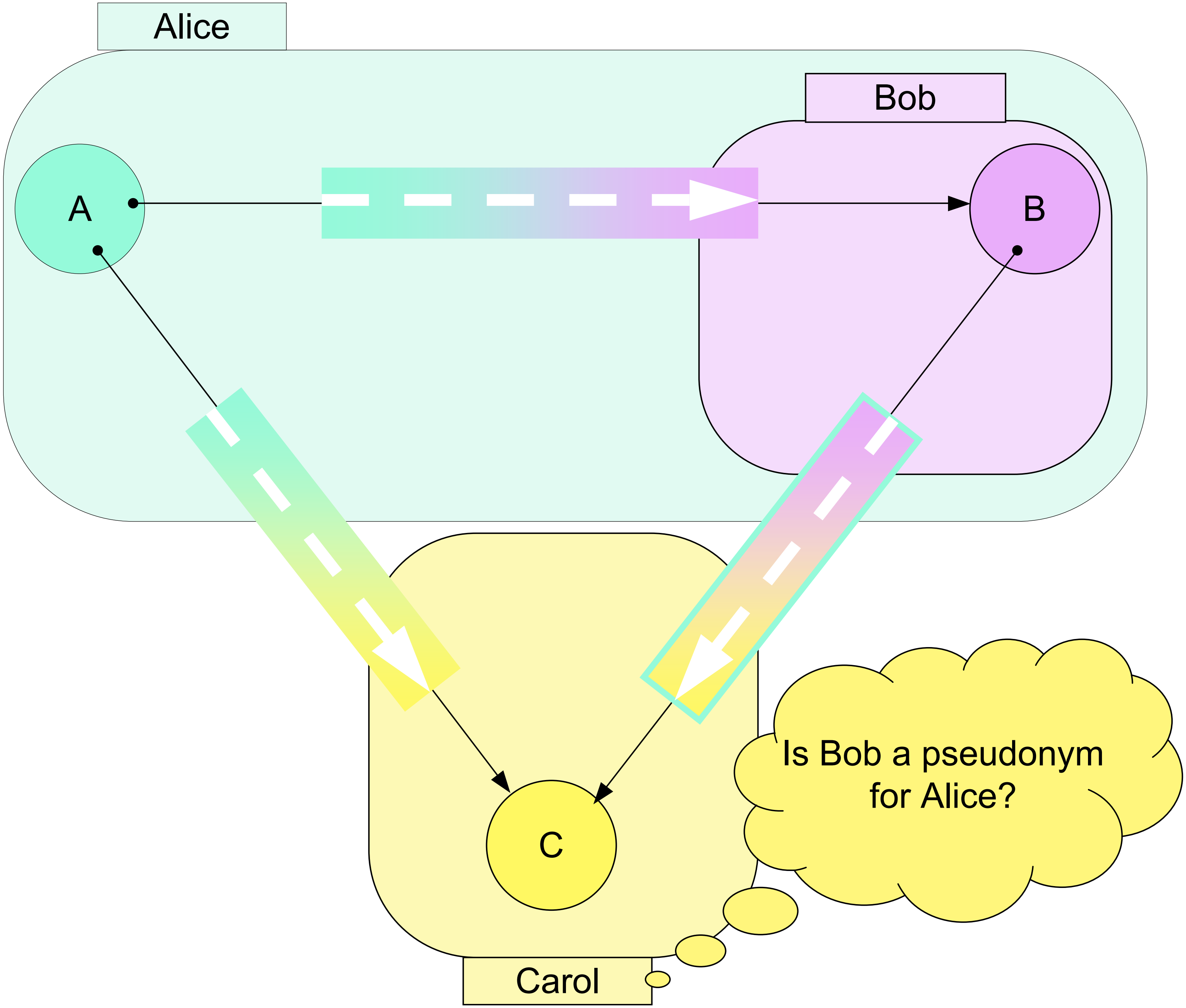

Alice
Bob
A
B
deliver("foo",[[•,•]])
Carol
To Bob
From Carol
C
Carol


Unwrap Carol's gift from Alice
Alice
Bob
A
deliver("foo",[[• , •]])
B
Carol
To Bob From Carol
C
Carol


Unwrap Carol's gift from Alice
Alice
Bob
A
foo( )
B
C
Carol

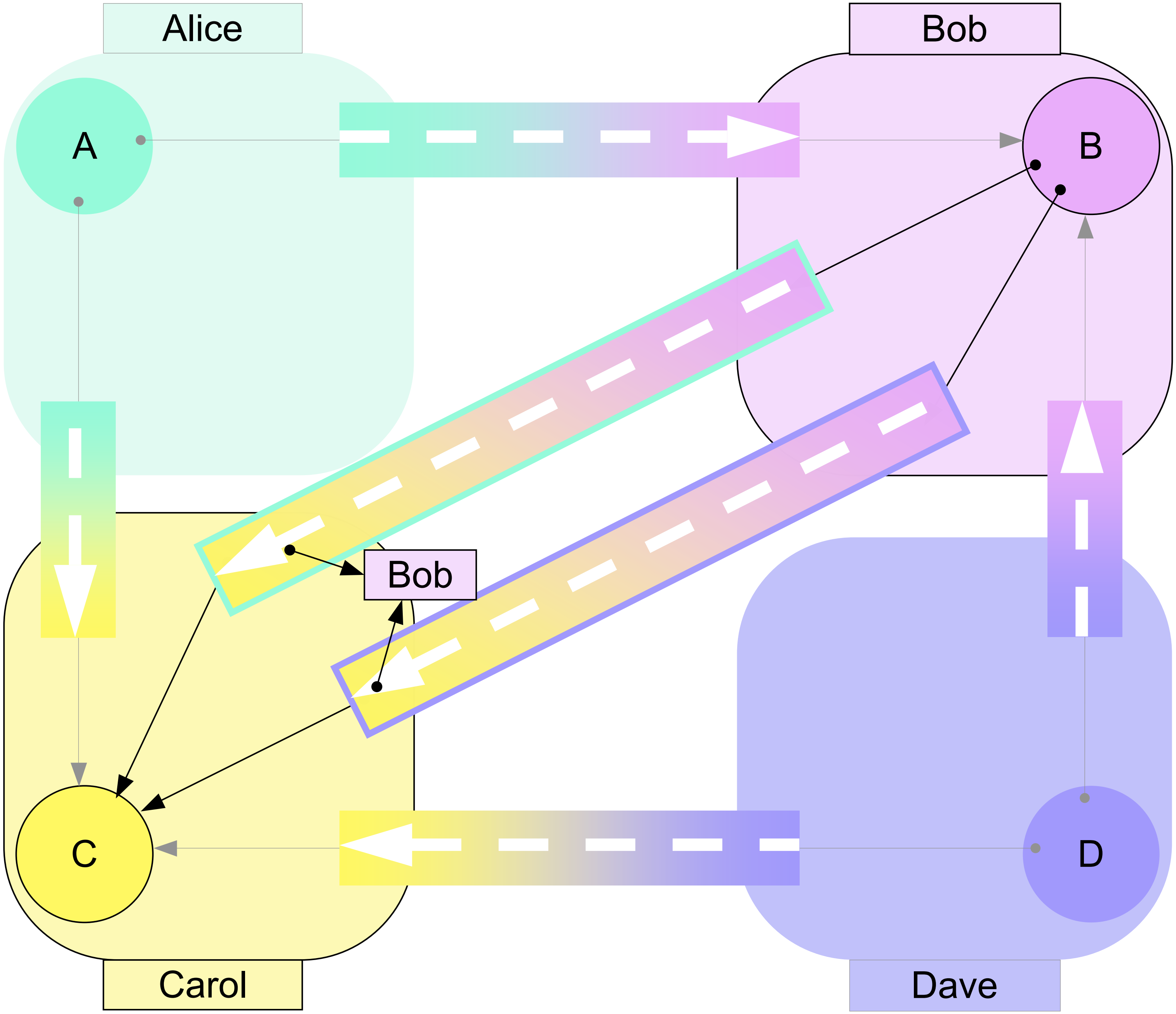

Alice
Bob
A
foo( )
B
C
Carol


Alice
Bob
A
B
C
Carol


Alice
Bob
A
B
C
Carol
Is Bob a pseudonym for Alice?

Four party intermediation

Only corroborating introductions
let Alice shed blame


Alice
Bob
A
B
Bob
C
D
Carol
Dave

Better Identities than ACLs

Fully decentralized

- No global administrator or name server

Track bilateral responsibility

- For requests and for service
- Also tracks delegation chain

Sybil resistant aggregation strategy

Corroboration-driven disaggregation

Conclusions

Delegate authority, bound to responsibility for using that authority.

Fine-grain least authority for safety.

Large-grain identities for damage control.

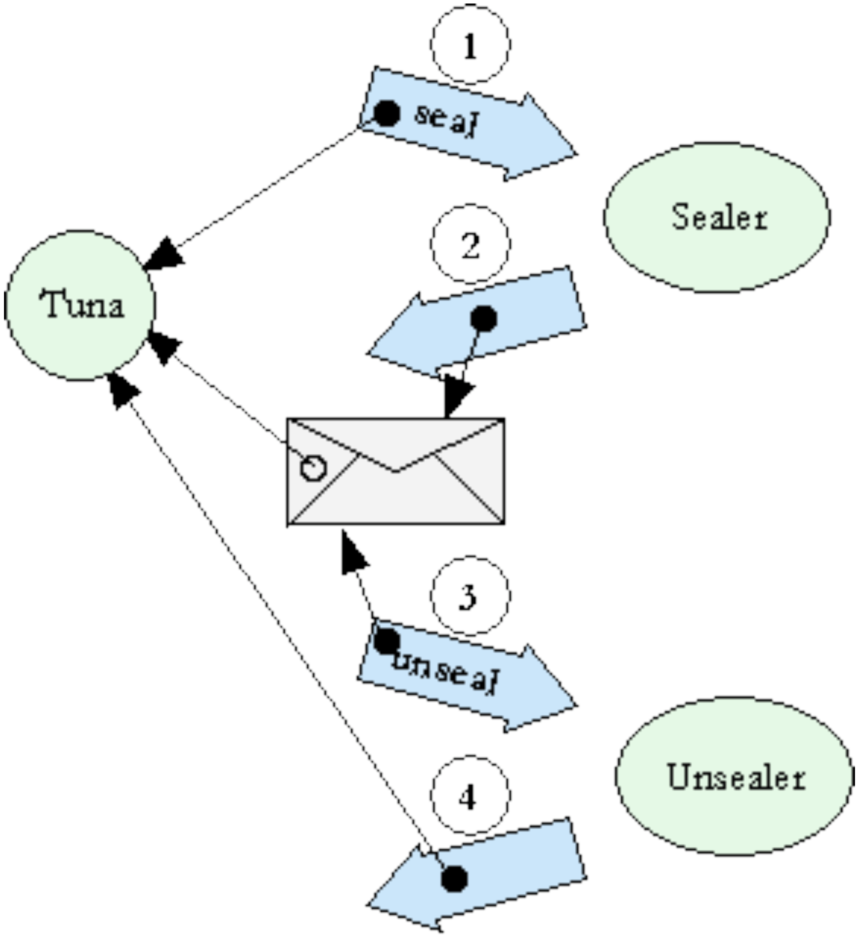
Reference implementations in Java & E:

http://erights.org/download/horton/

Three-party intermediation

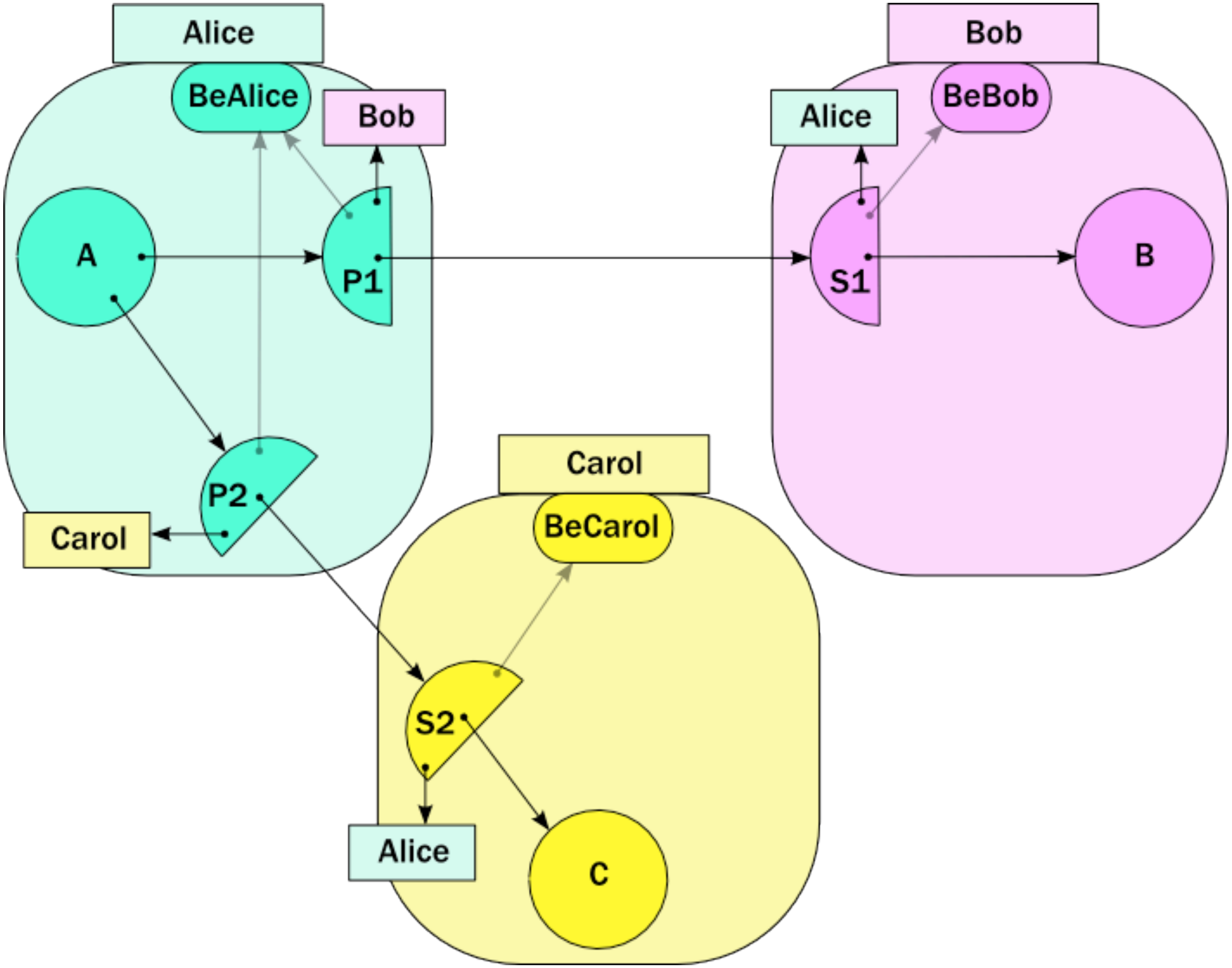
The details

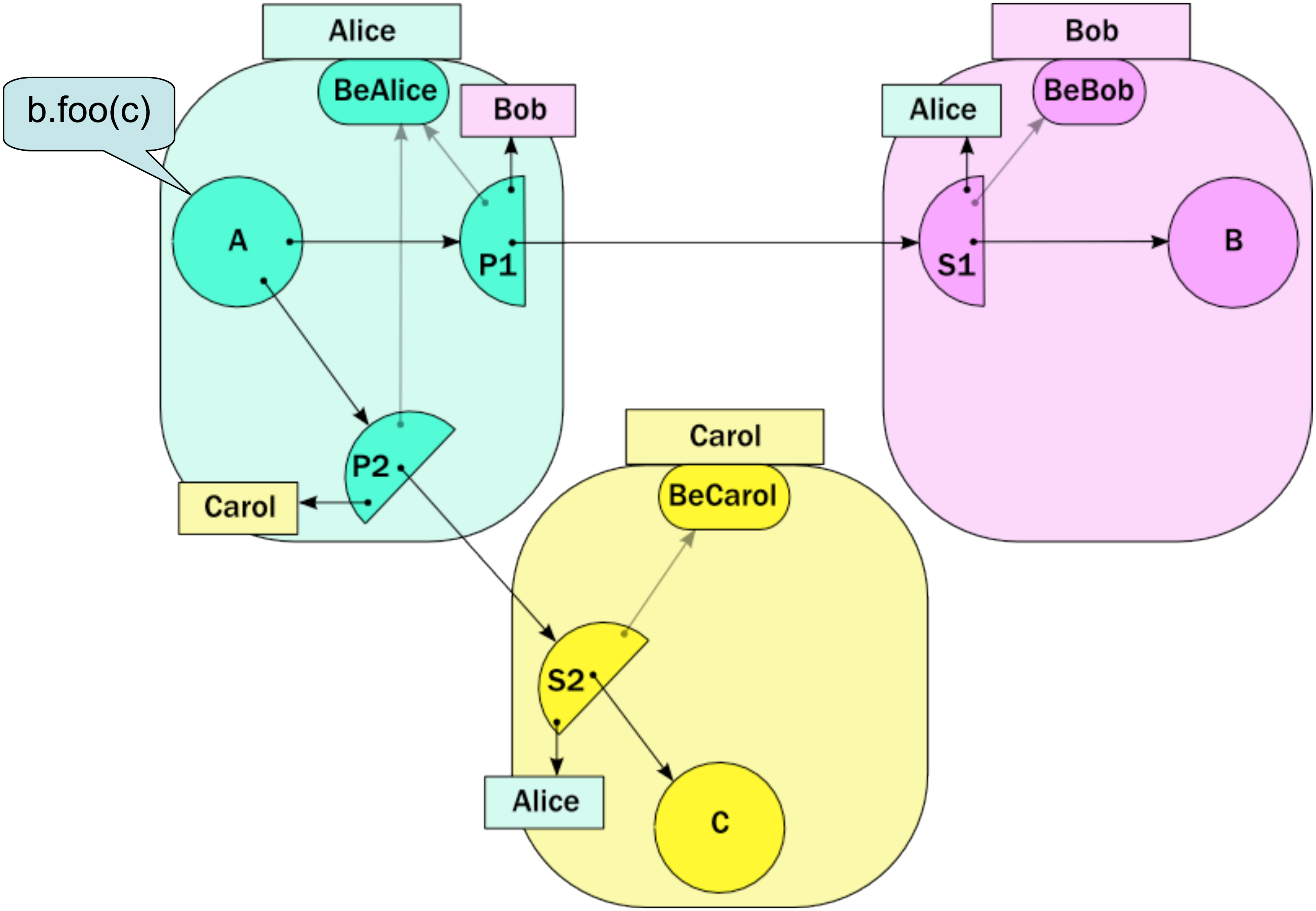
Rights Amplification

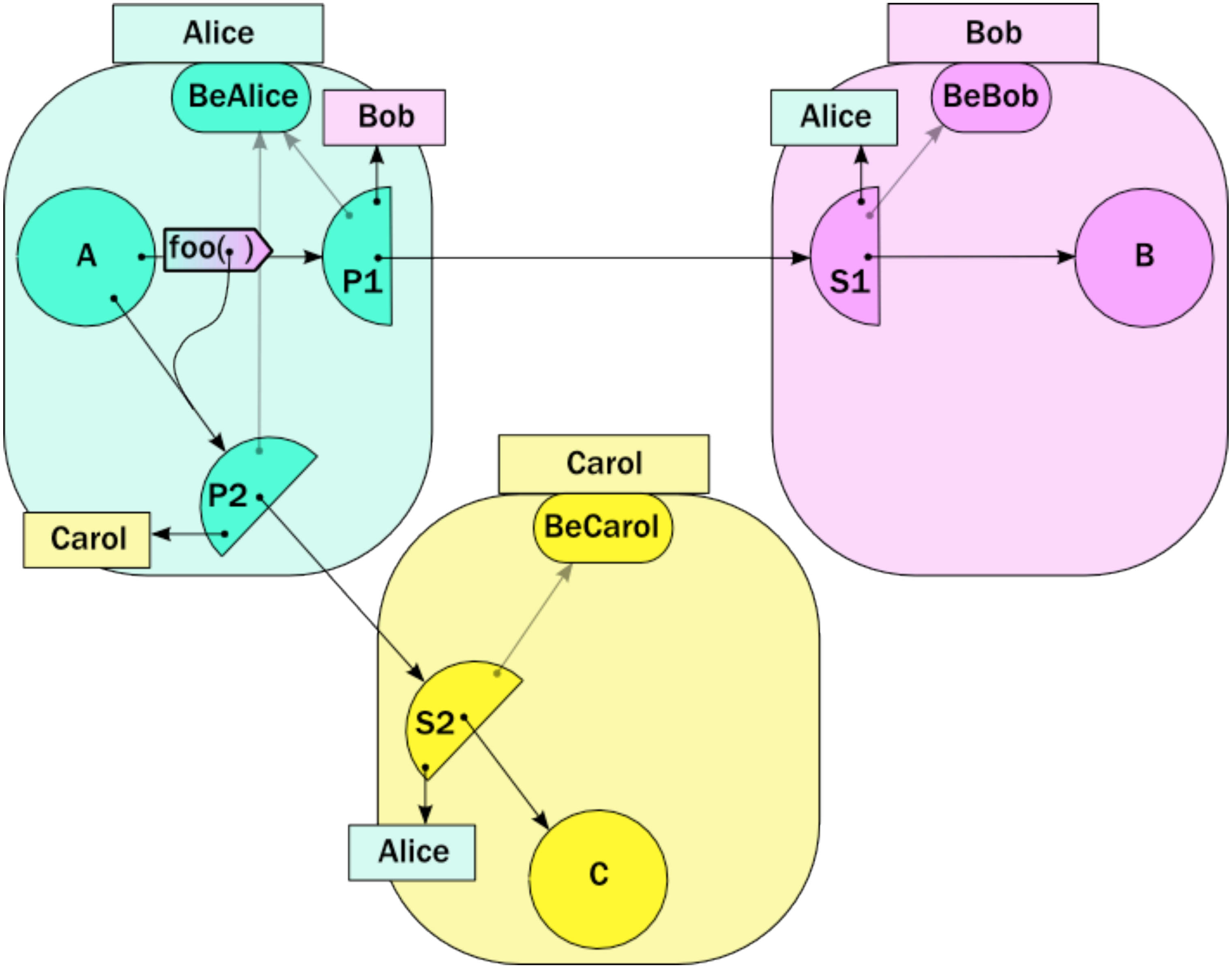


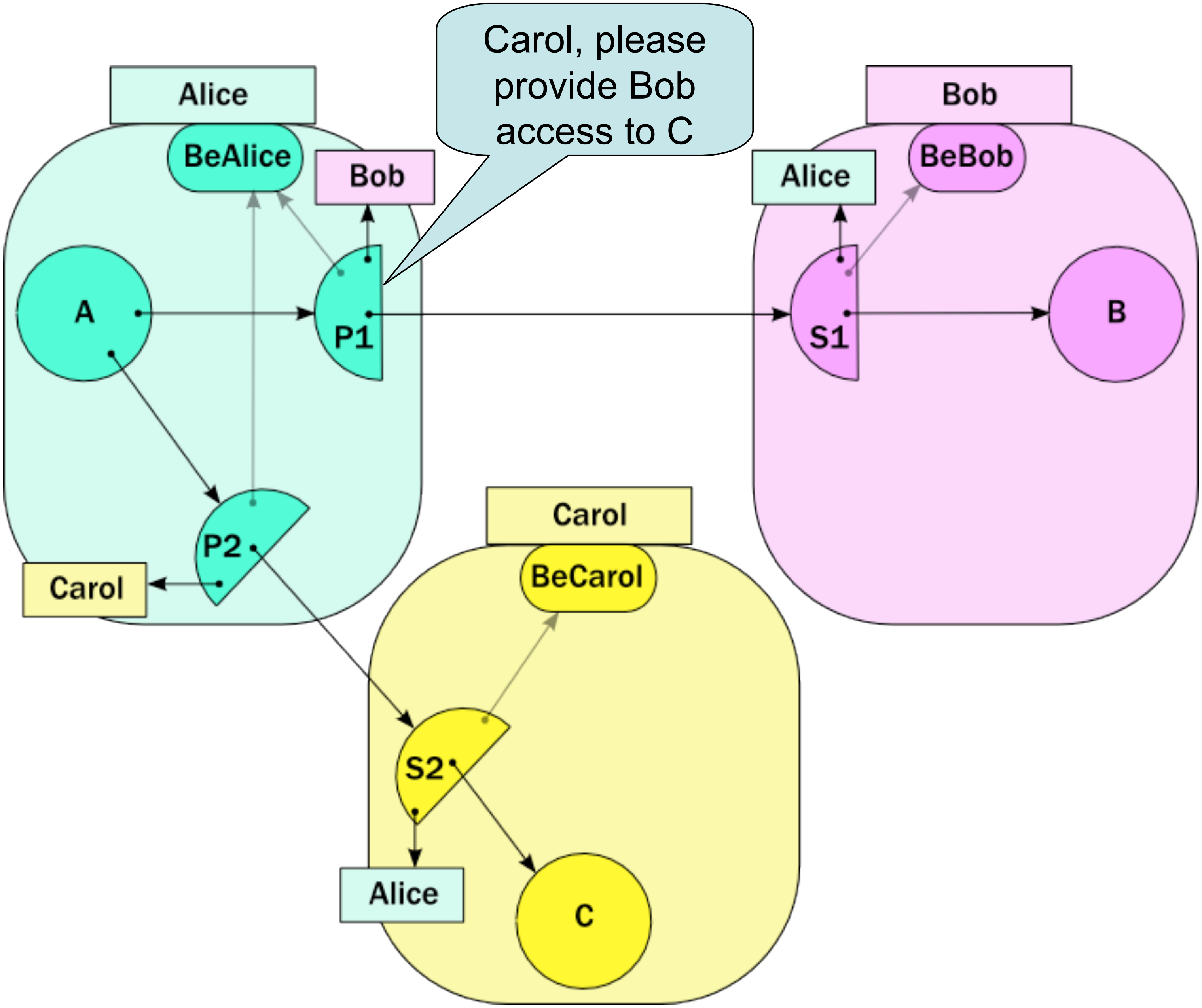
- Inspired by PK
- Simple oo pattern
- No explicit crypto

- Can represent responsible identity

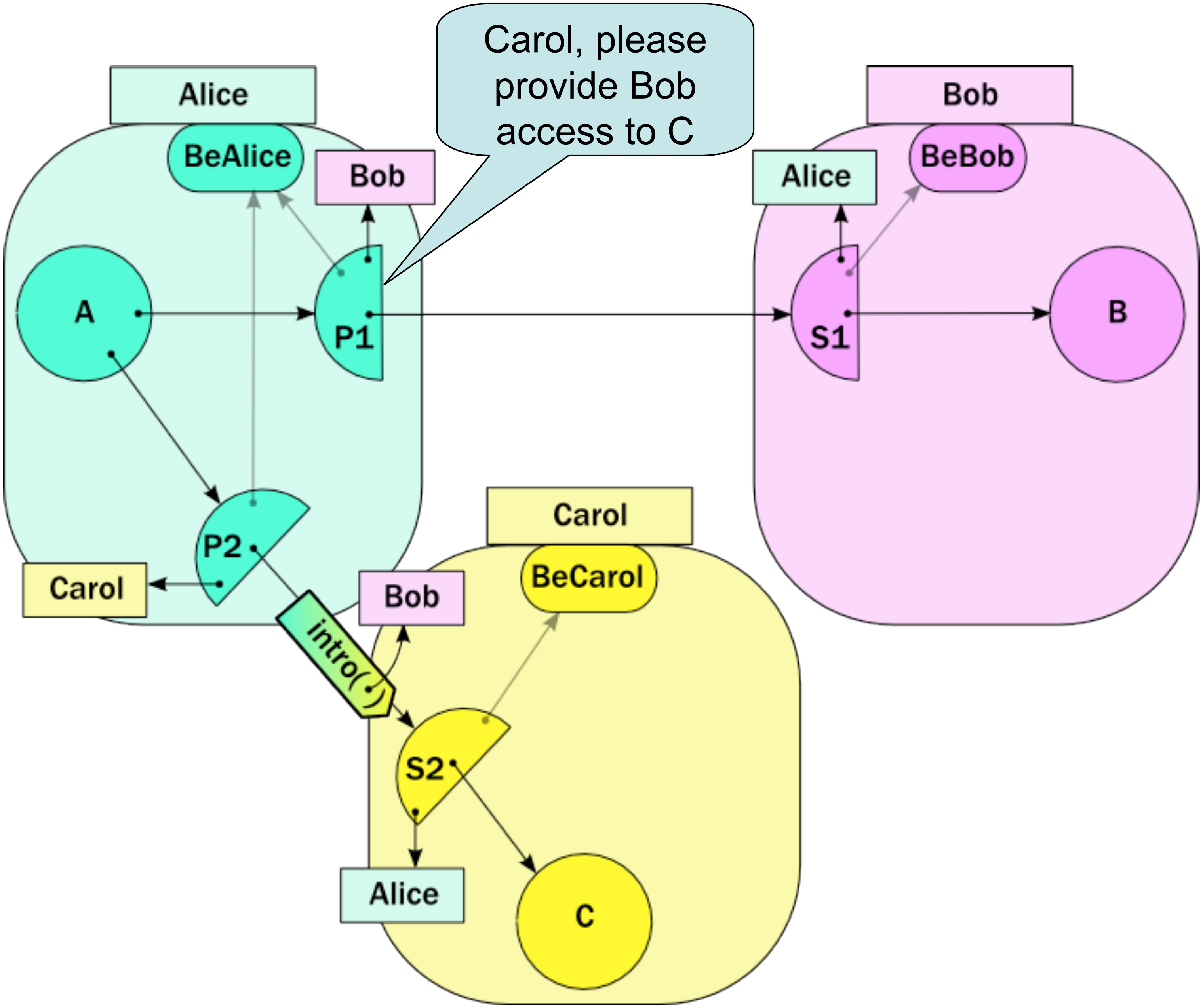

Alice
BeAlice
Bob
A
P1
P2
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
S2
Alice
C


b.foo(c)
Alice
BeAlice
Bob
A
P1
P2
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
S2
Alice
C

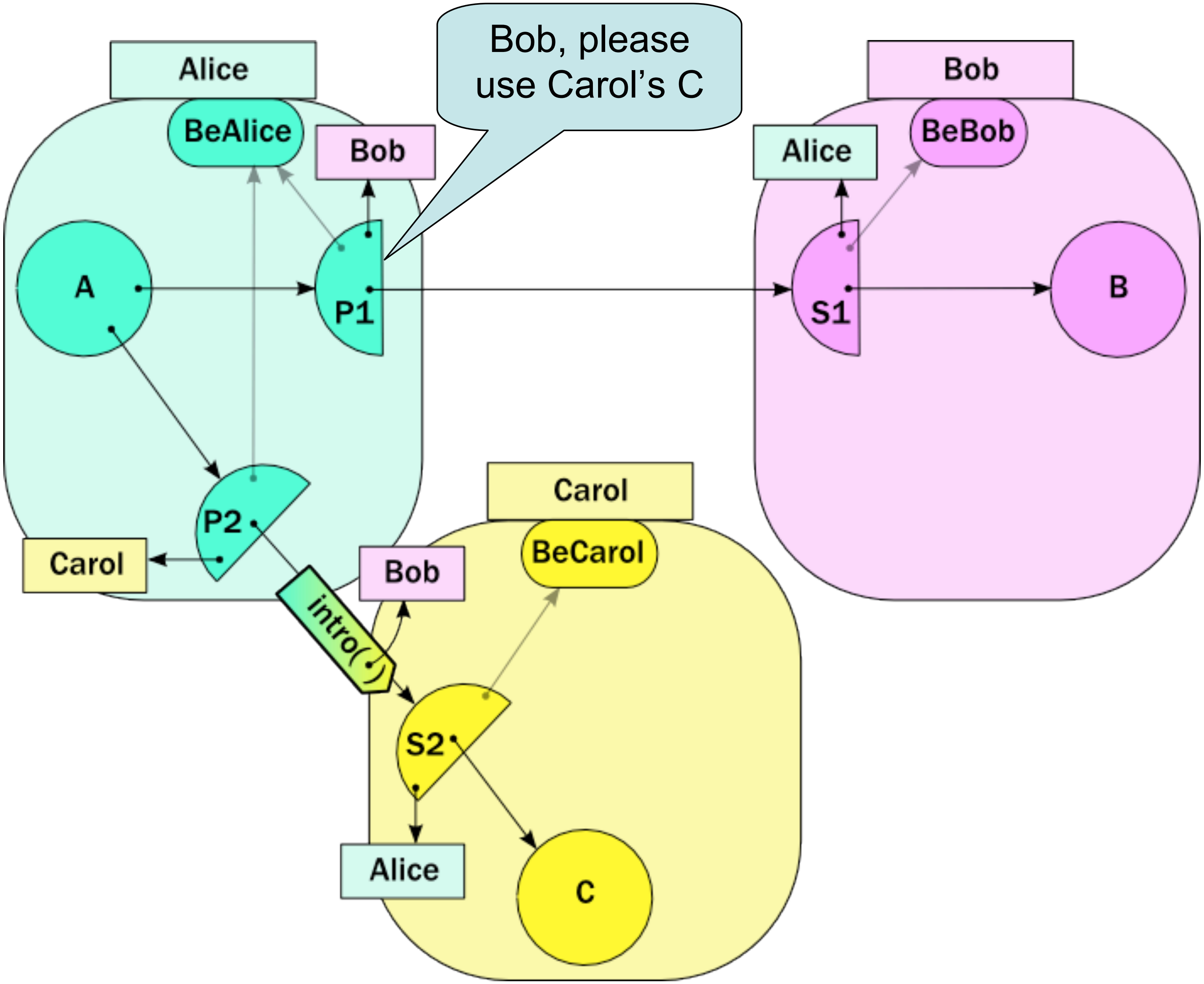

Alice
BeAlice
Bob
A
foo( )
P1
P2
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
S2
Alice
C

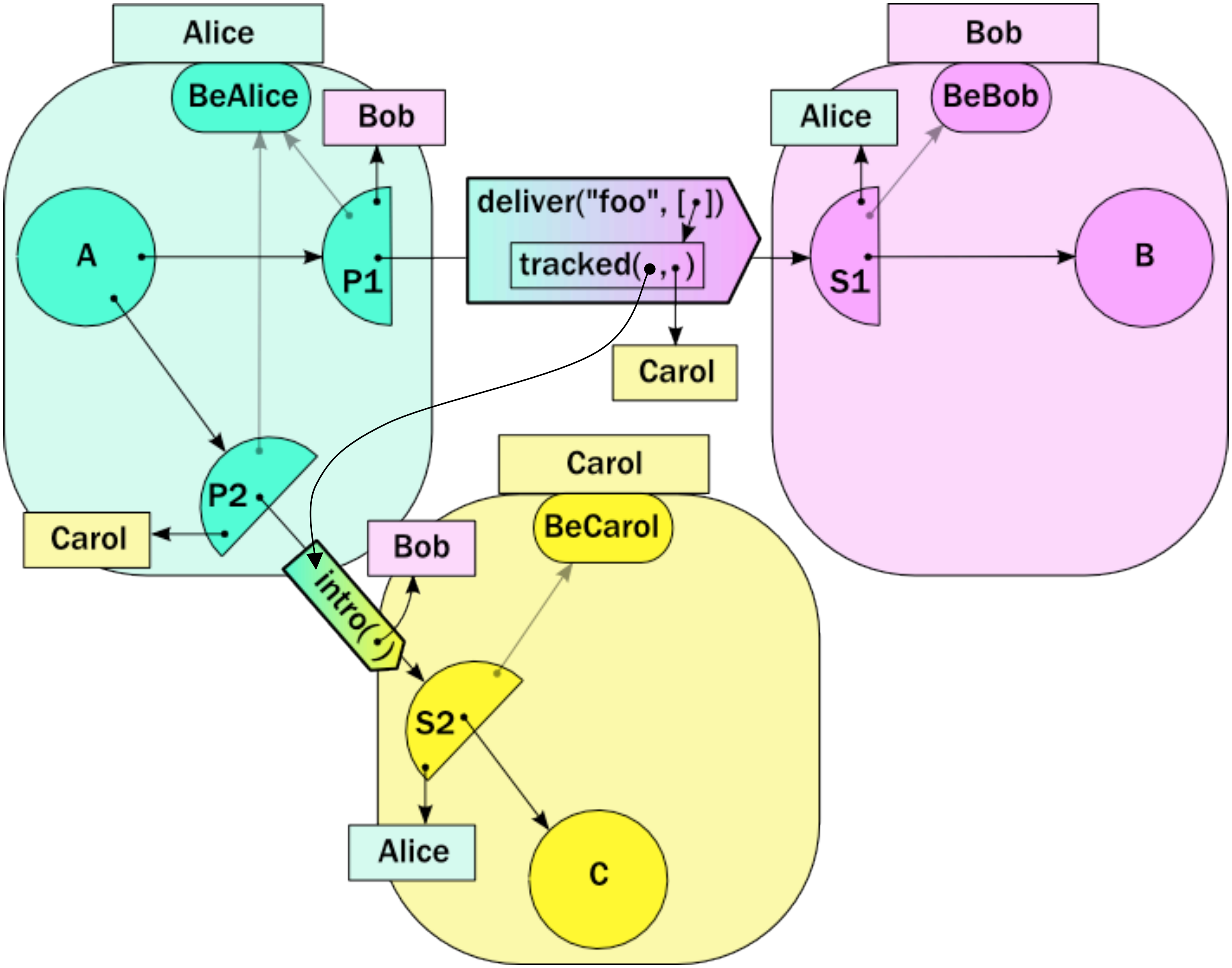


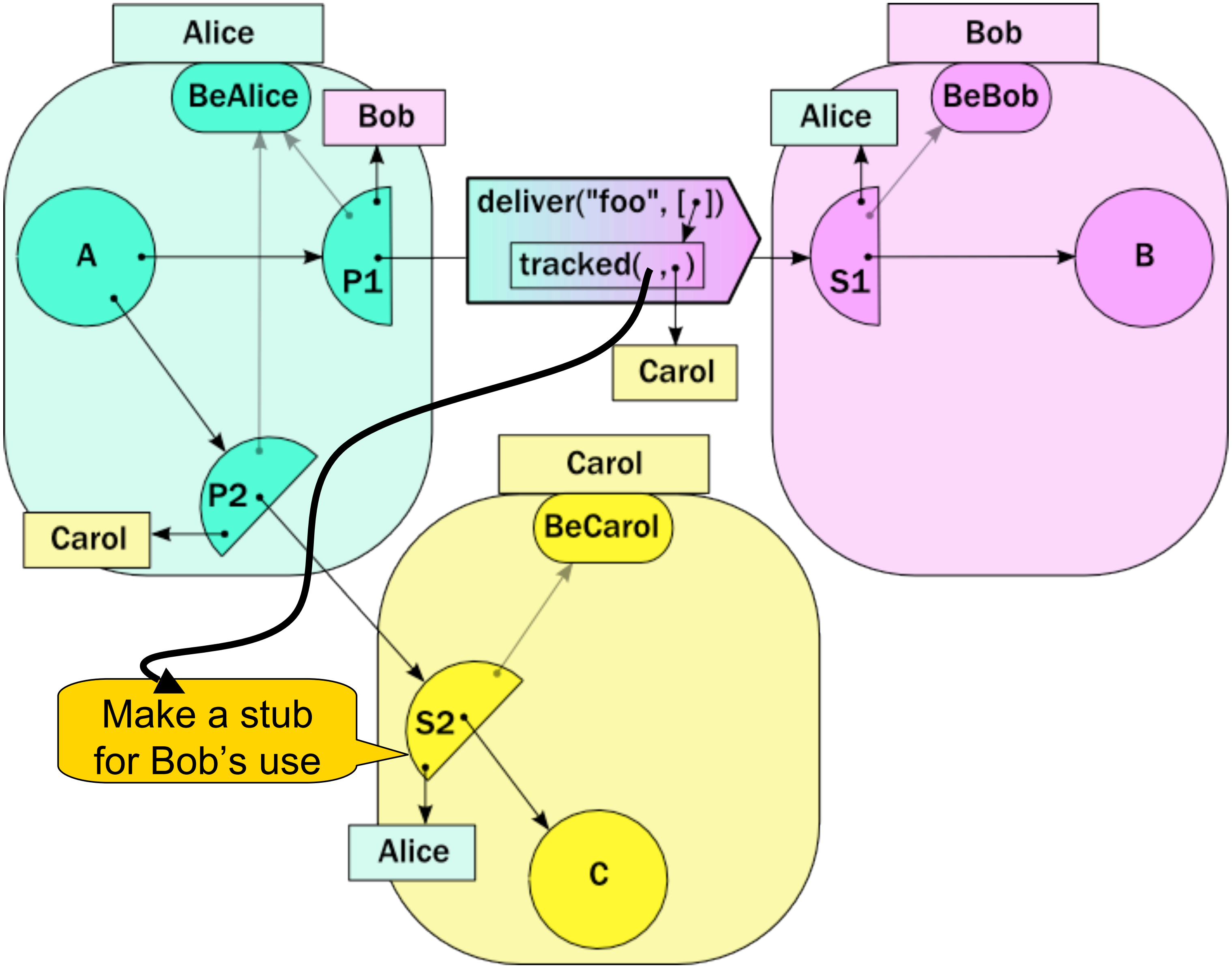
Carol, please provide Bob access to C



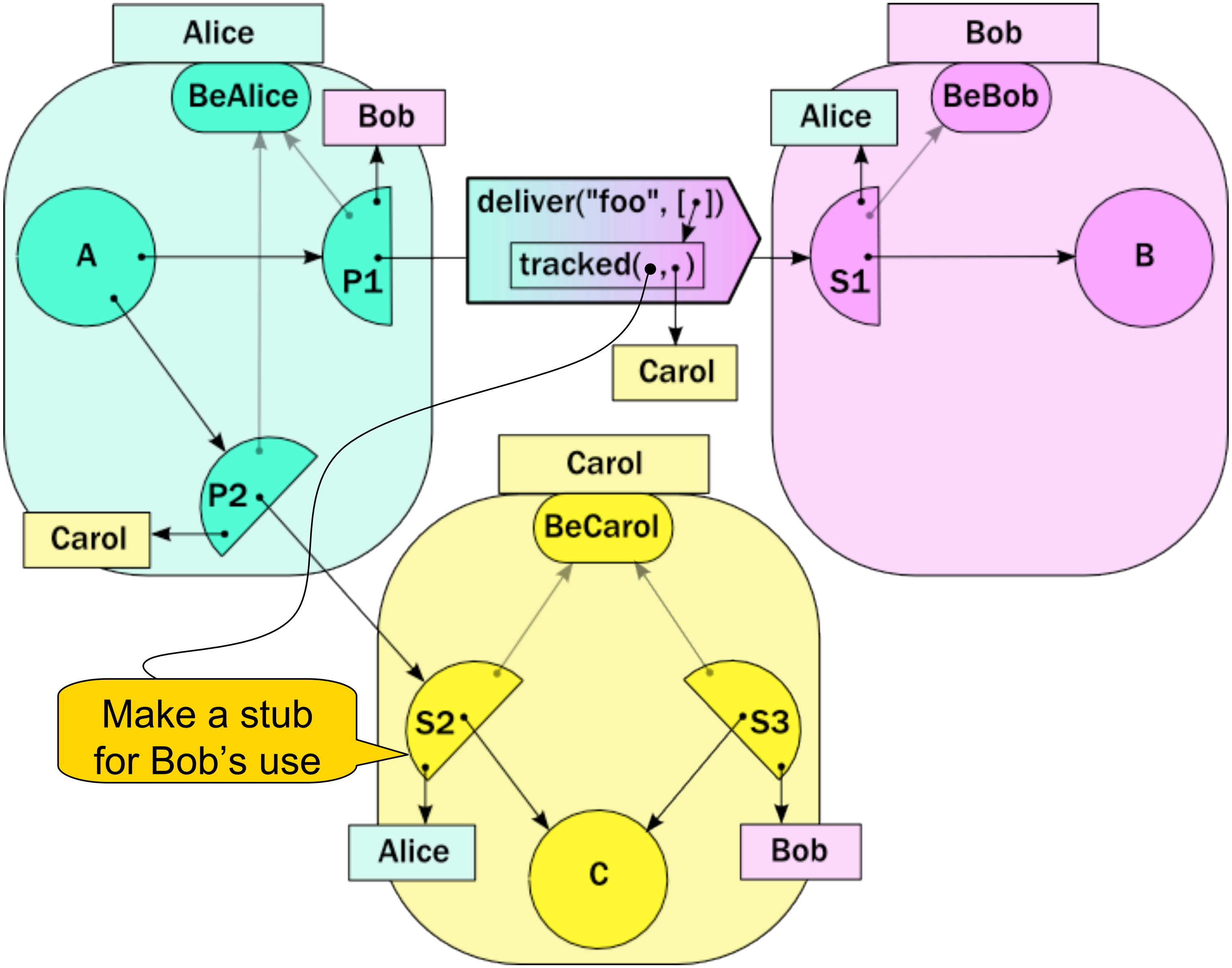
Carol, please provide Bob access to C


Bob, please use Carol's C
Alice
BeAlice
Bob
A
P1
P2
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
Bob
intro( )
S2
Alice
C

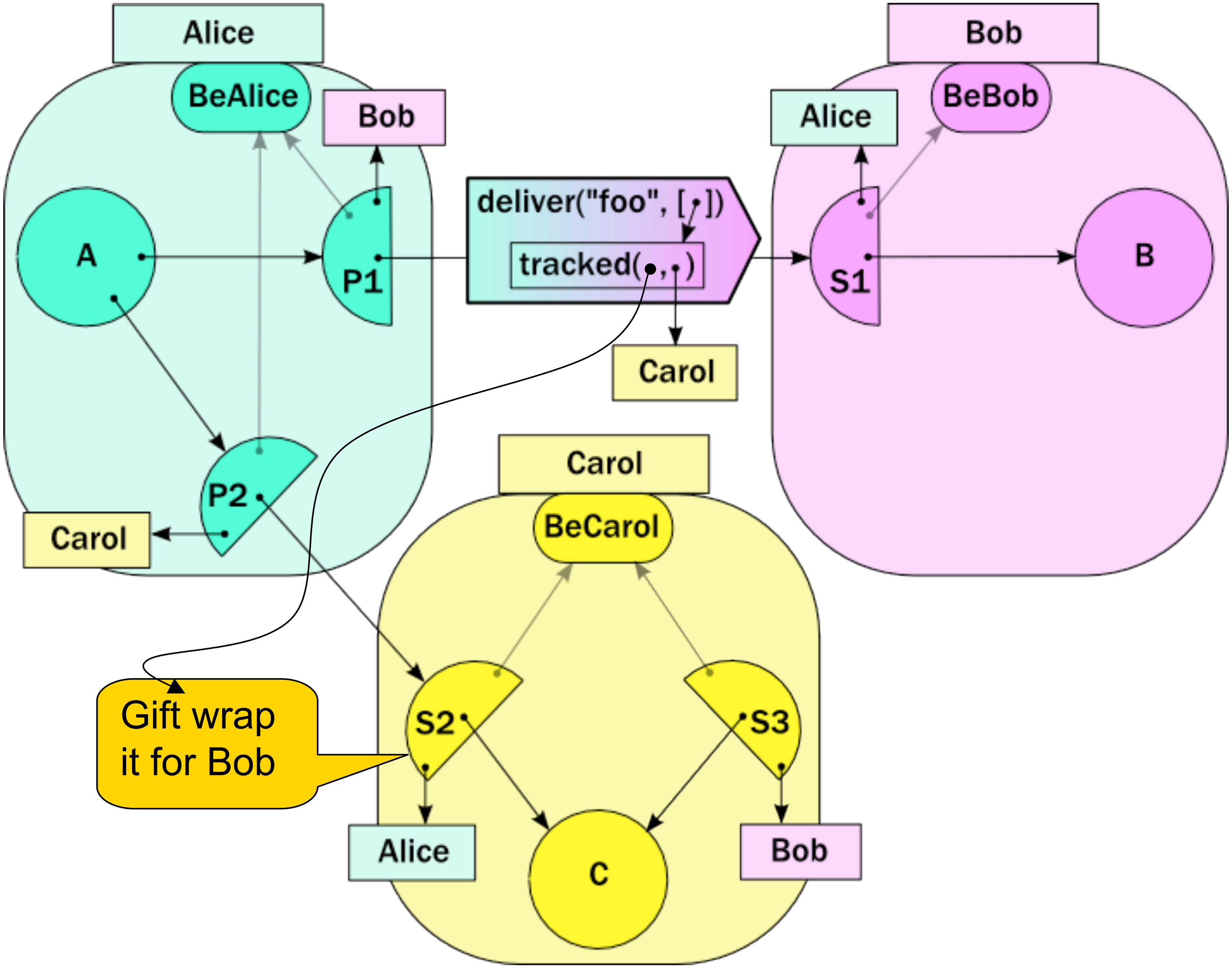

Alice
BeAlice
Bob
A
P1
deliver("foo", [ ])
tracked(,)
Carol
Bob
BeBob
Alice
S1
B
P2
Carol
Carol
BeCarol
Bob
intro( )
S2
Alice
C

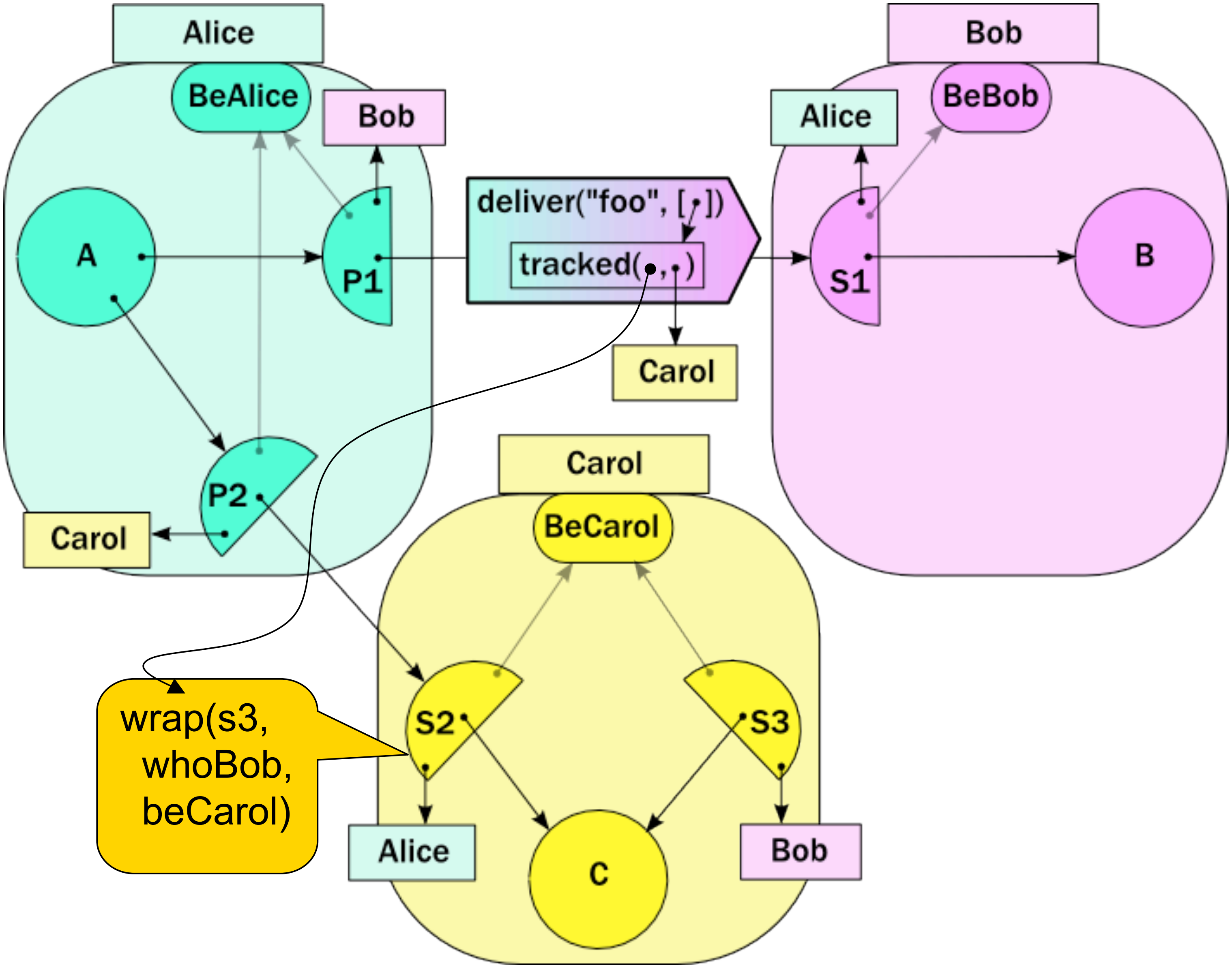


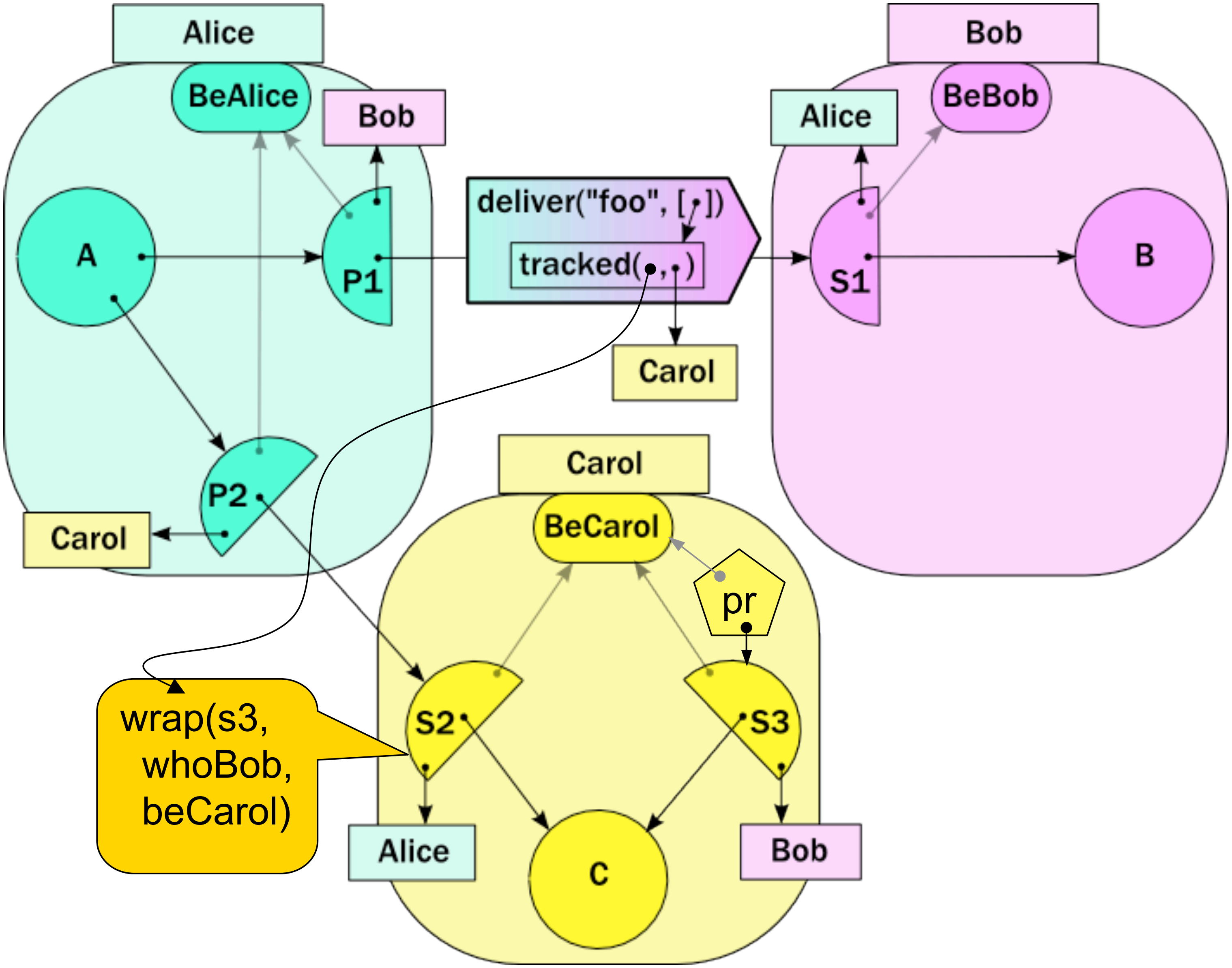
Make a stub for Bob’s use

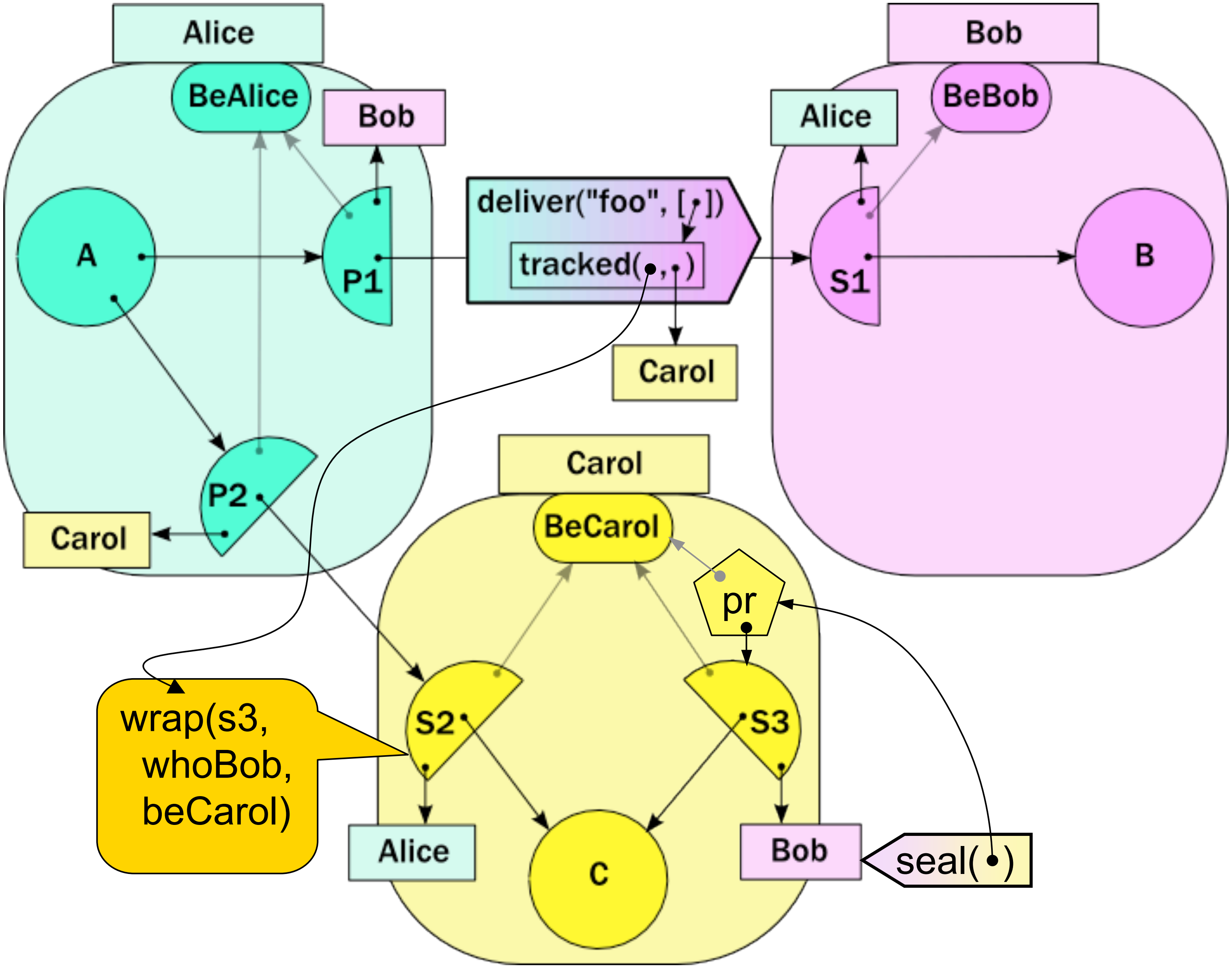


Make a stub for Bob's use

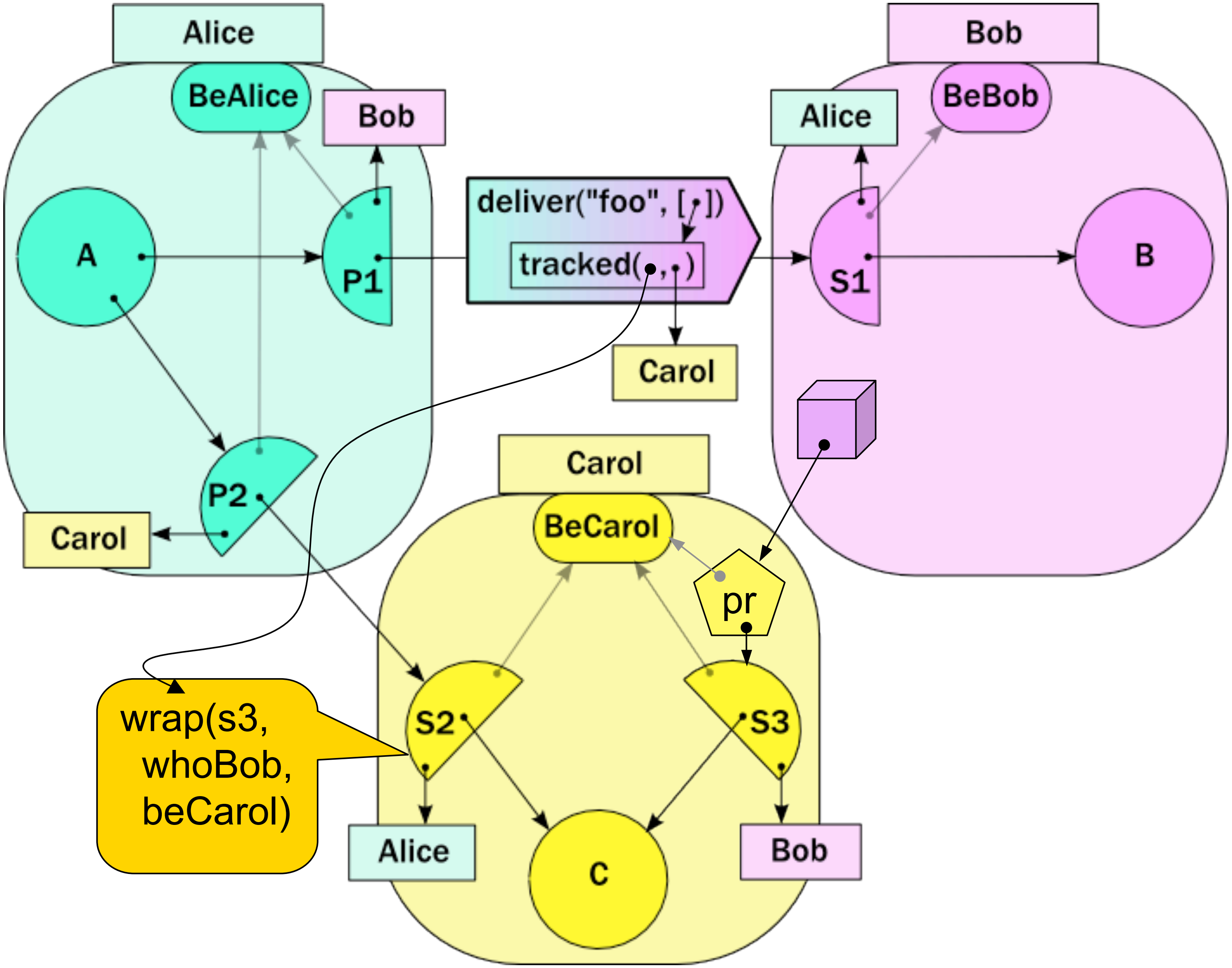

Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [ ])
tracked(,)
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
S2
S3
Alice
C
Bob
Gift wrap it for Bob

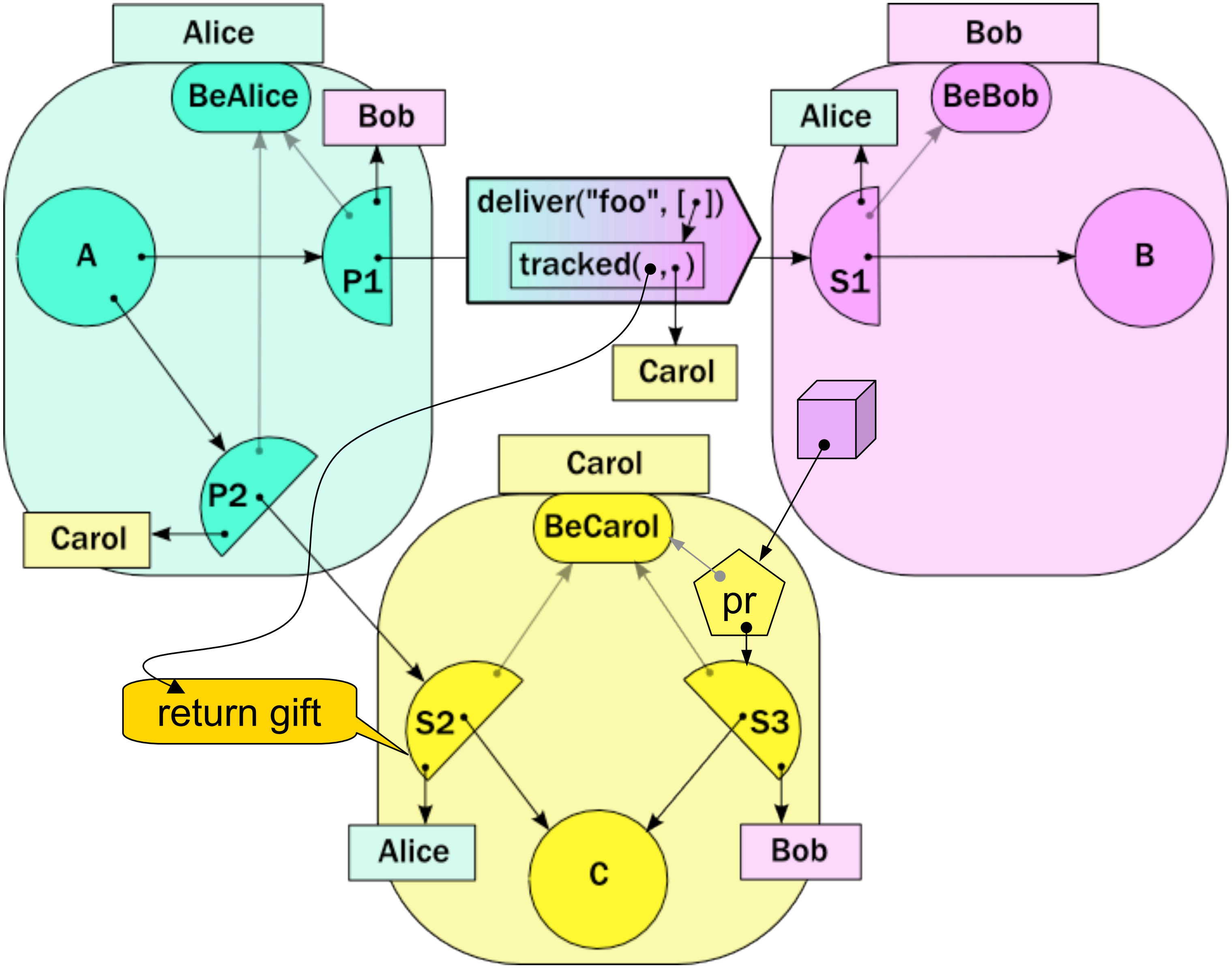

Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [,])
tracked(,,)
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
S2
S3
Alice
C
Bob
wrap(s3,
whoBob,
beCarol)


Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [ ])
tracked(,)
Carol
Bob
Alice
BeBob
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob
wrap(s3,
whoBob,
beCarol)

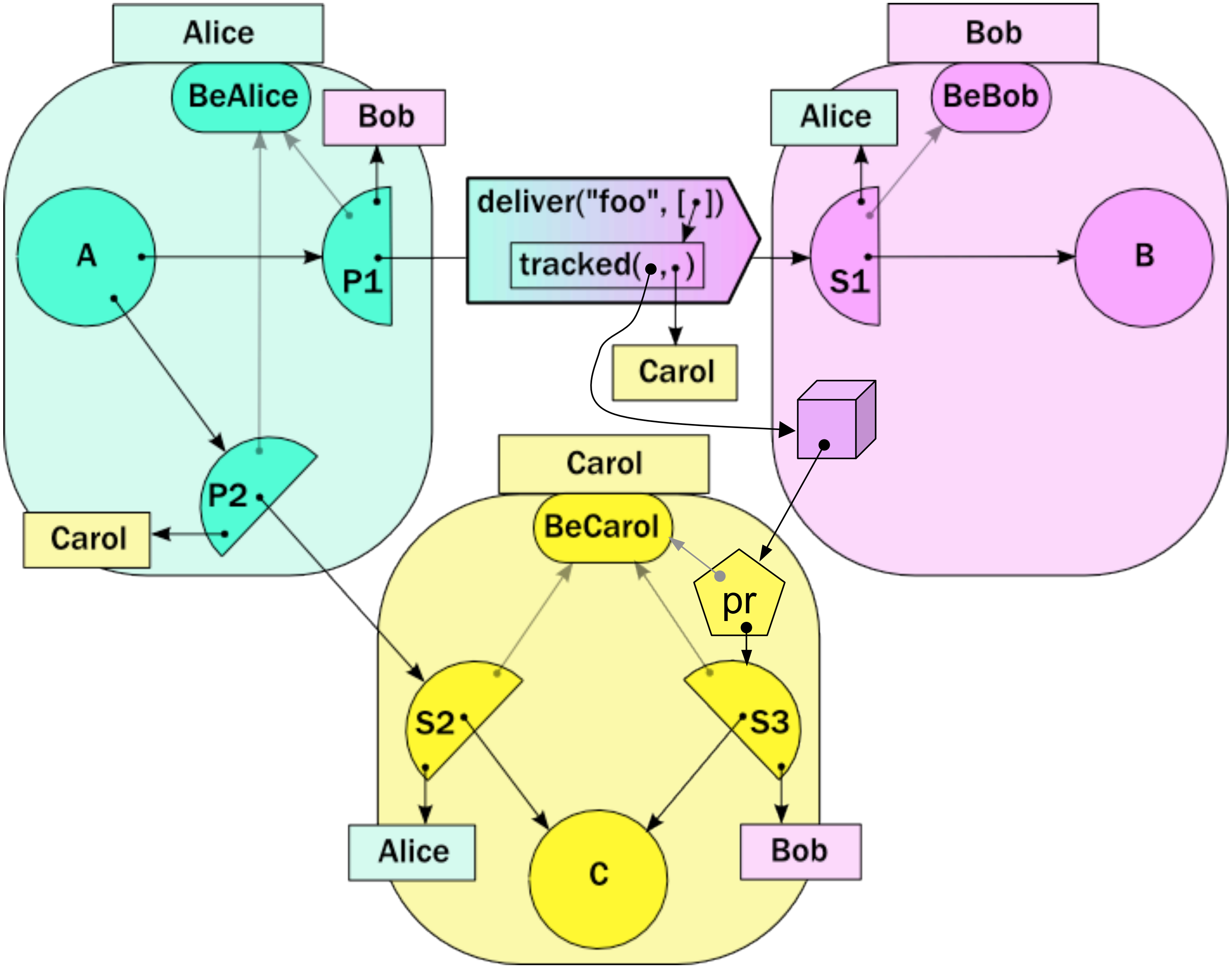


wrap(s3,
whoBob,
beCarol)

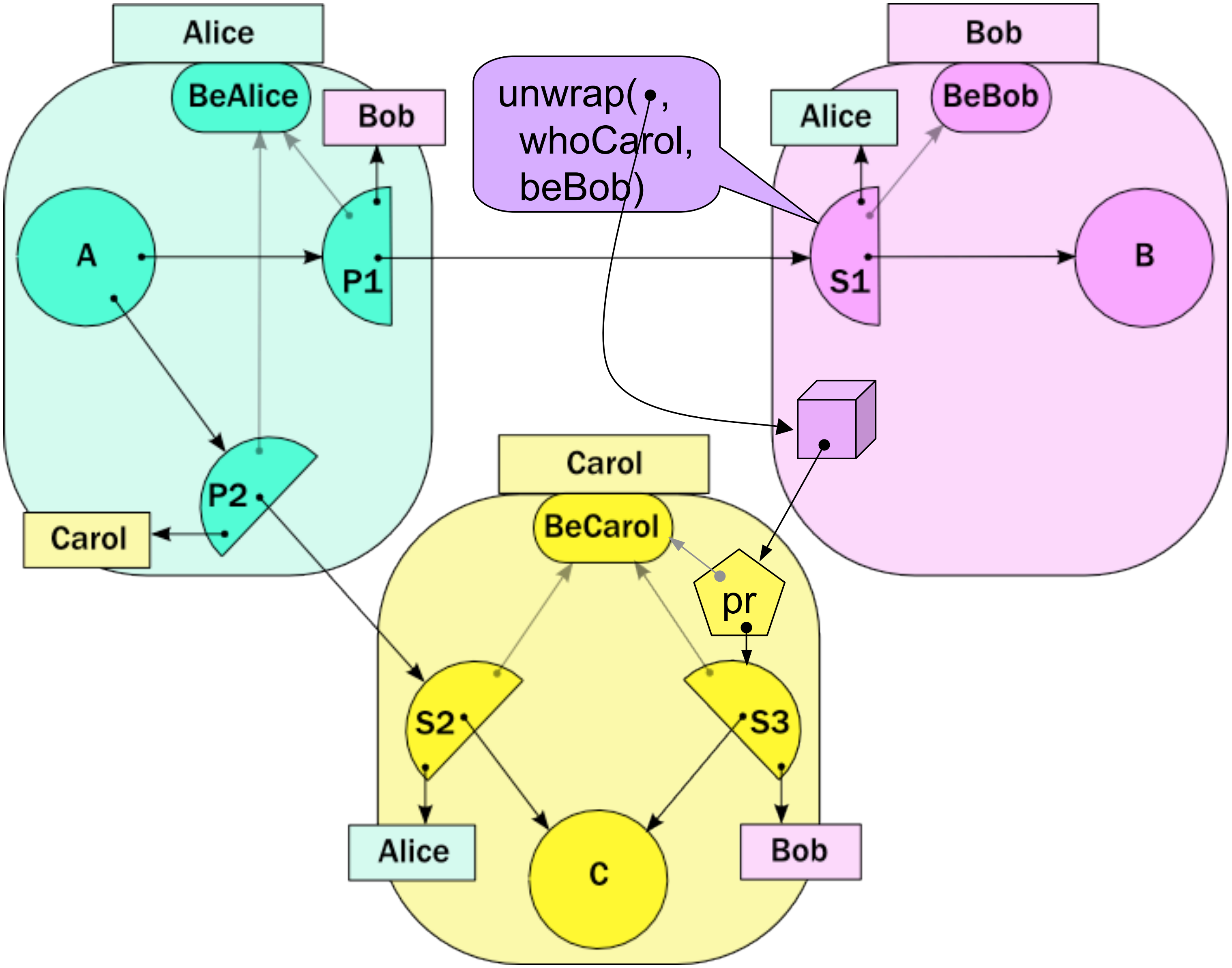

Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [ ])
tracked(,)
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob
wrap(s3,
whoBob,
beCarol)

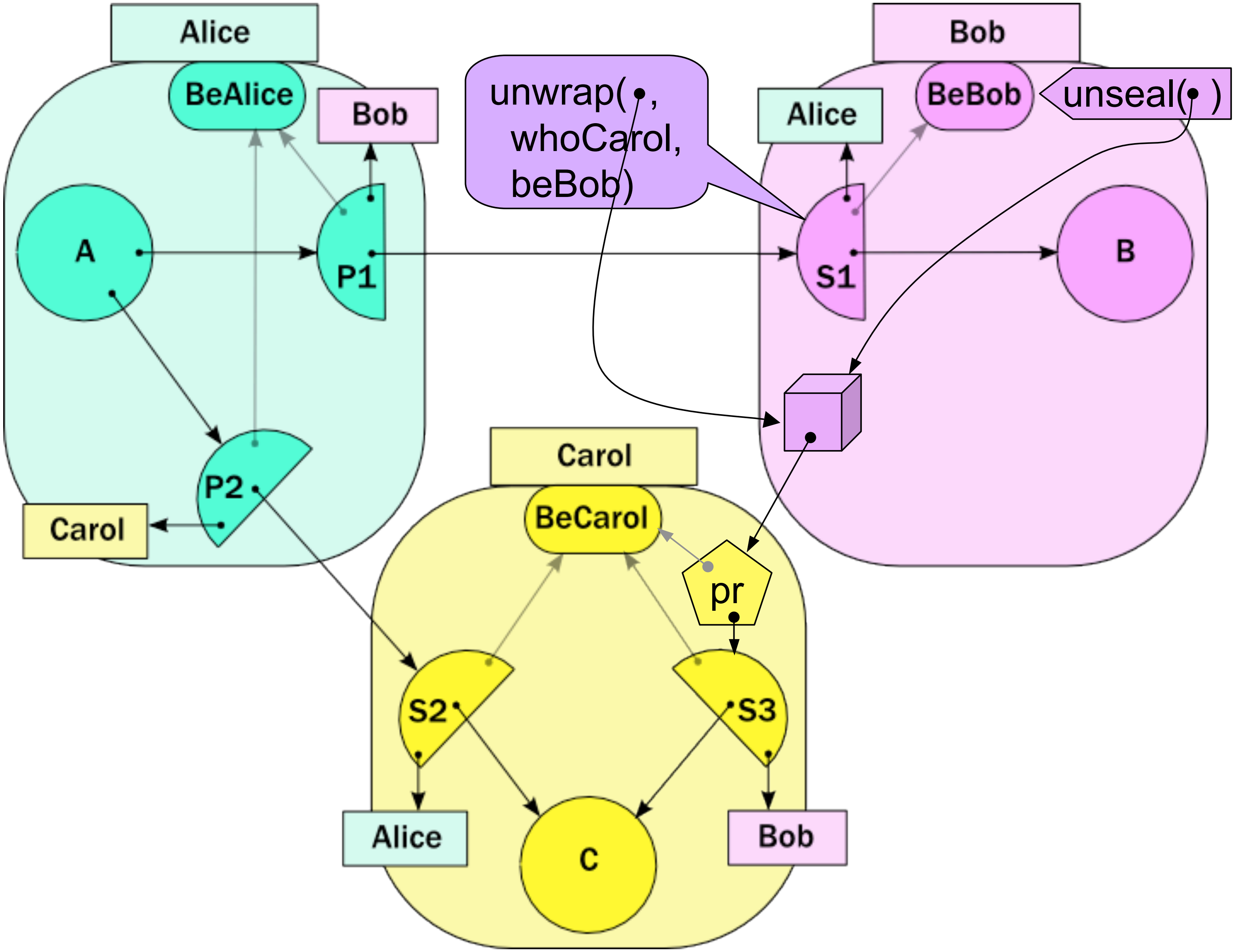


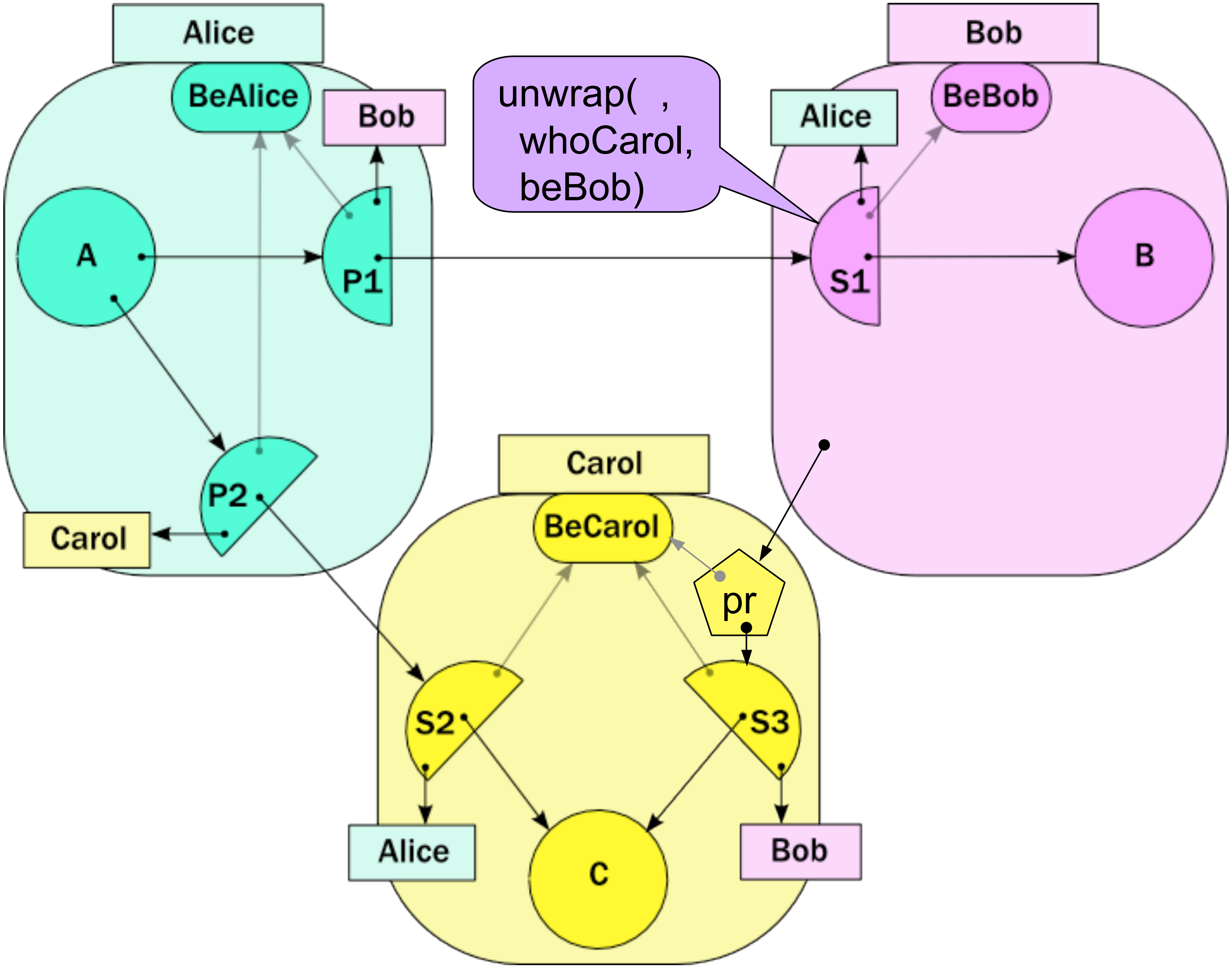
Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [ ])
tracked(, ,)
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob
return gift

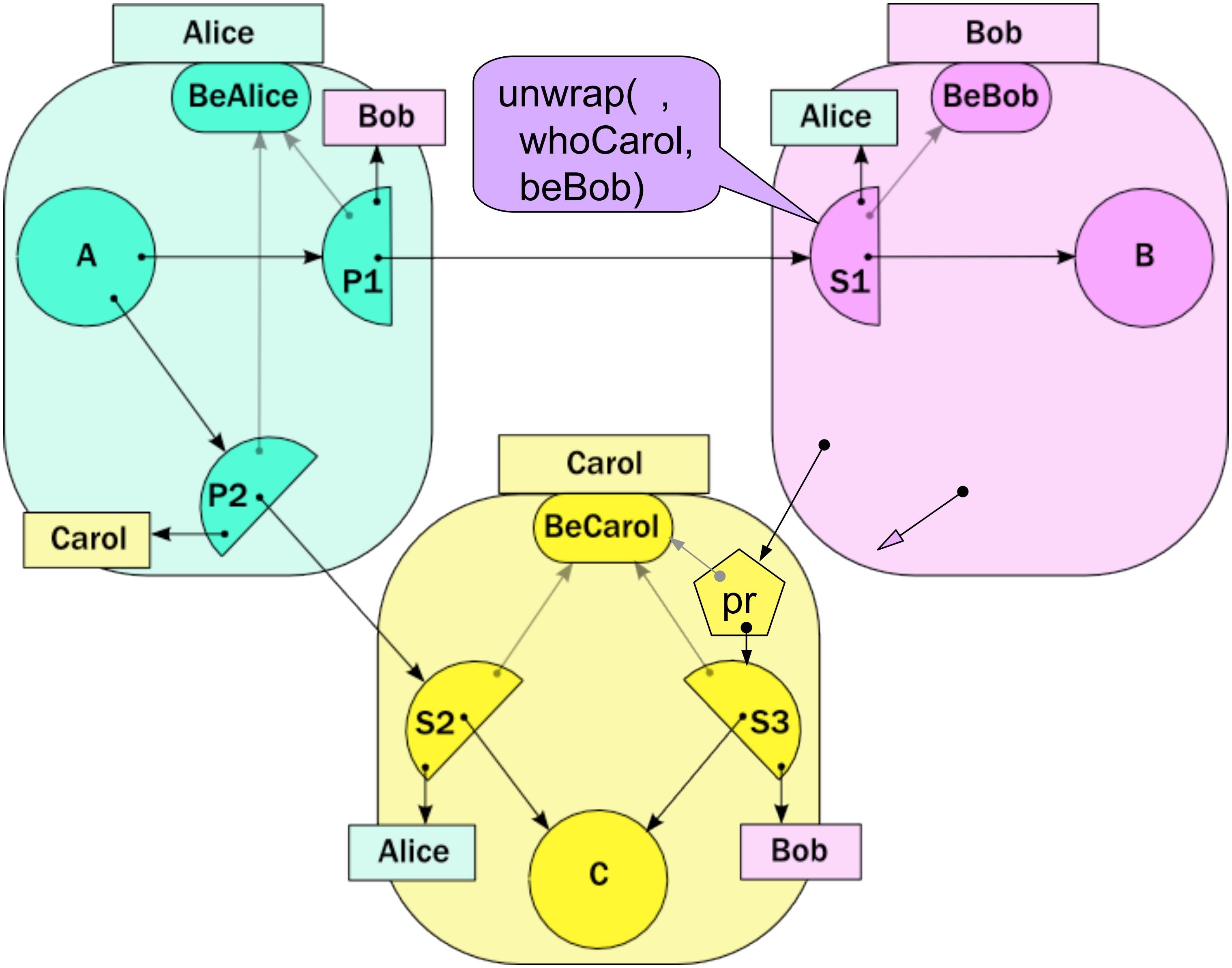


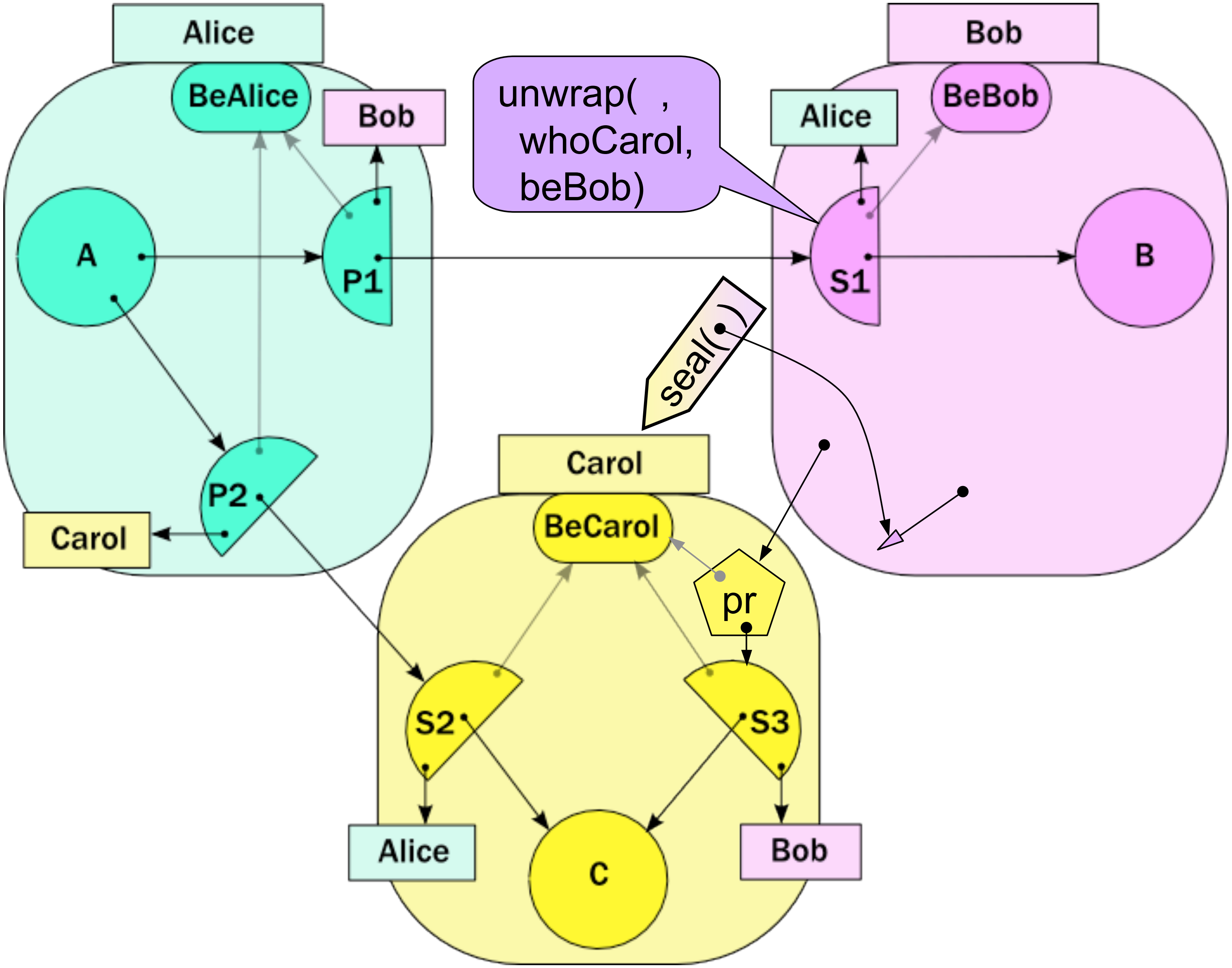
Alice
BeAlice
Bob
A
P1
P2
Carol
deliver("foo", [ ])
tracked(,)
Carol
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

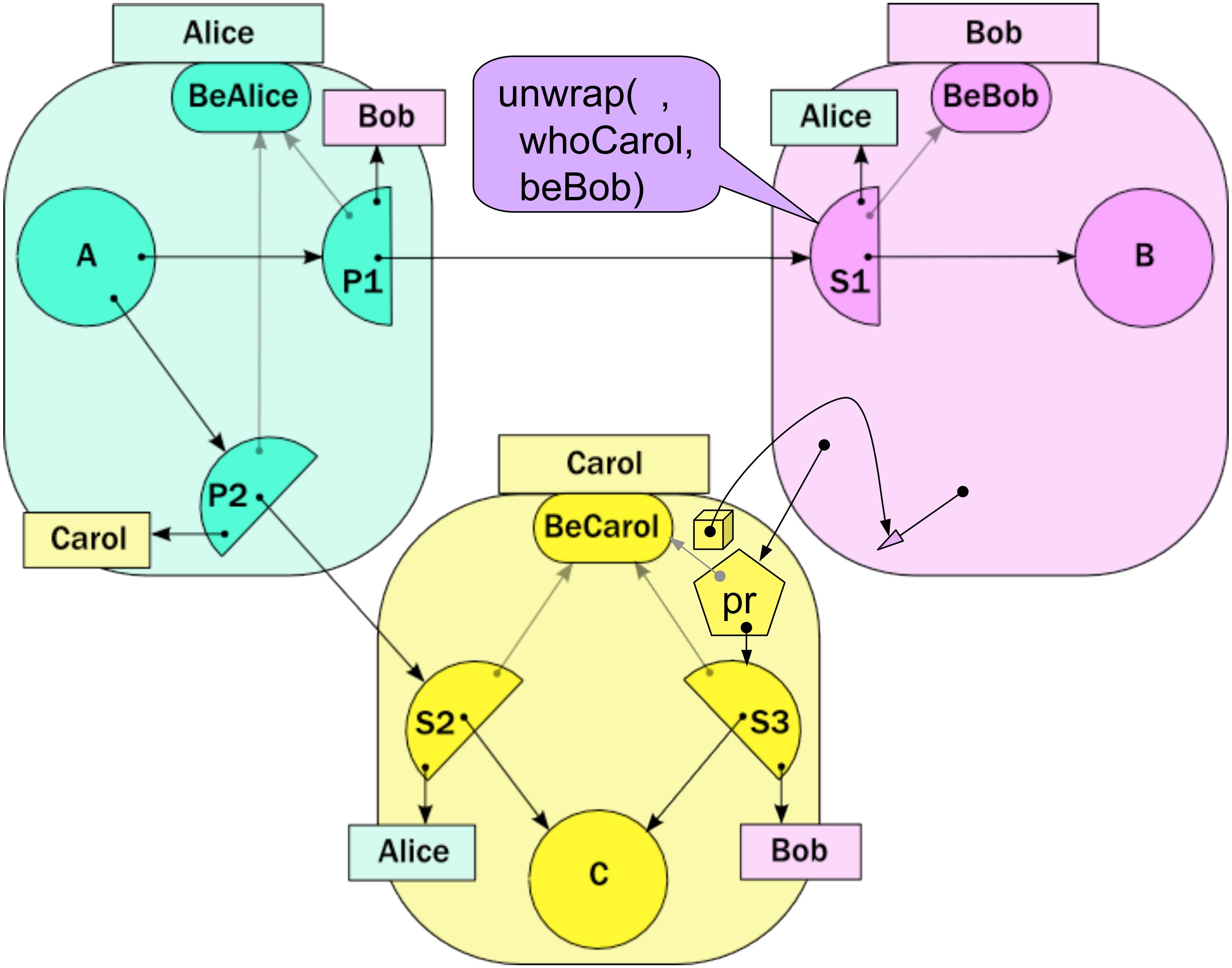

Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(•,
whoCarol,
beBob)
Bob
Alice
BeBob
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob


Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(, whoCarol, beBob)
Bob
Alice
BeBob
unseal( )
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

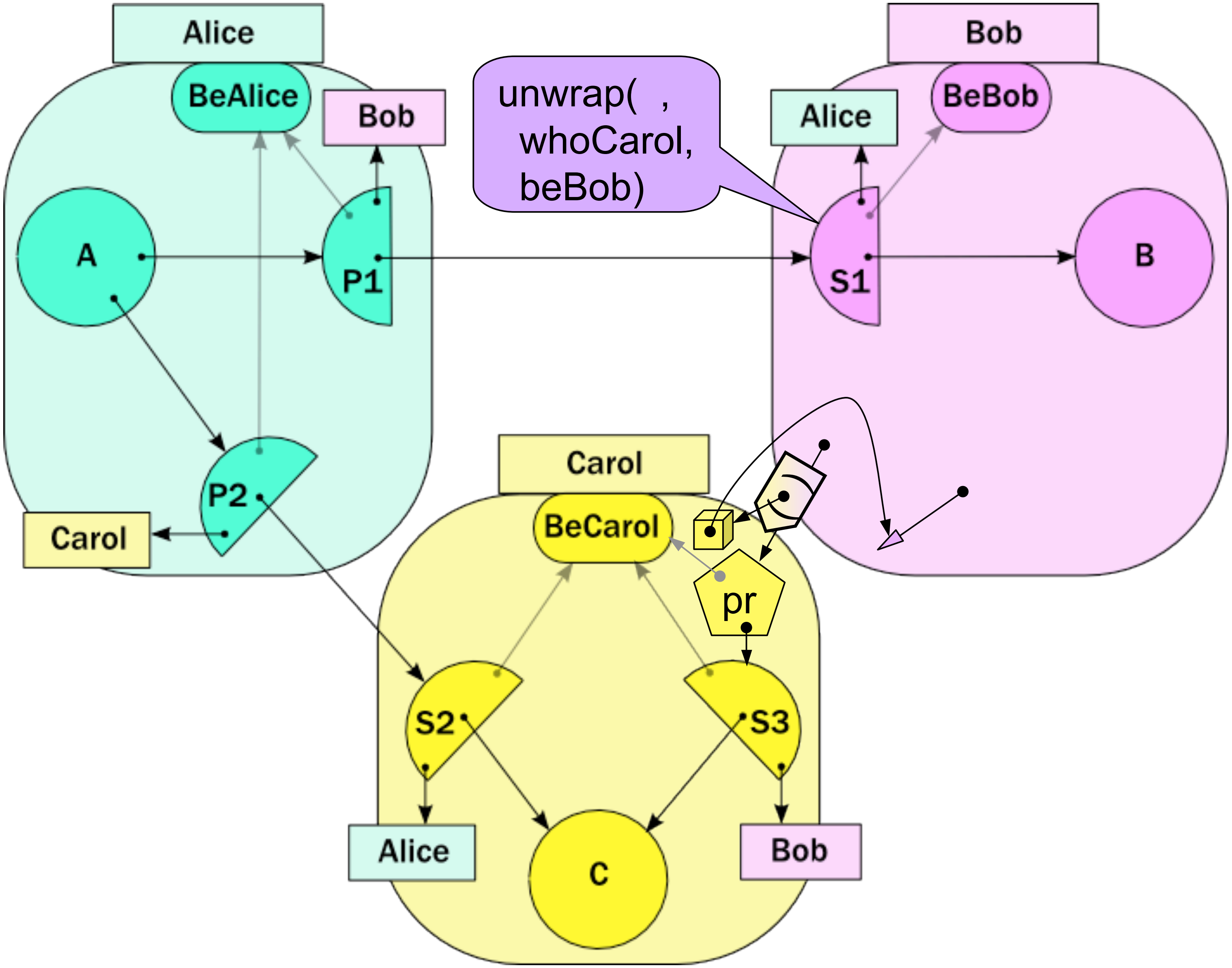

Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
Alice
BeBob
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

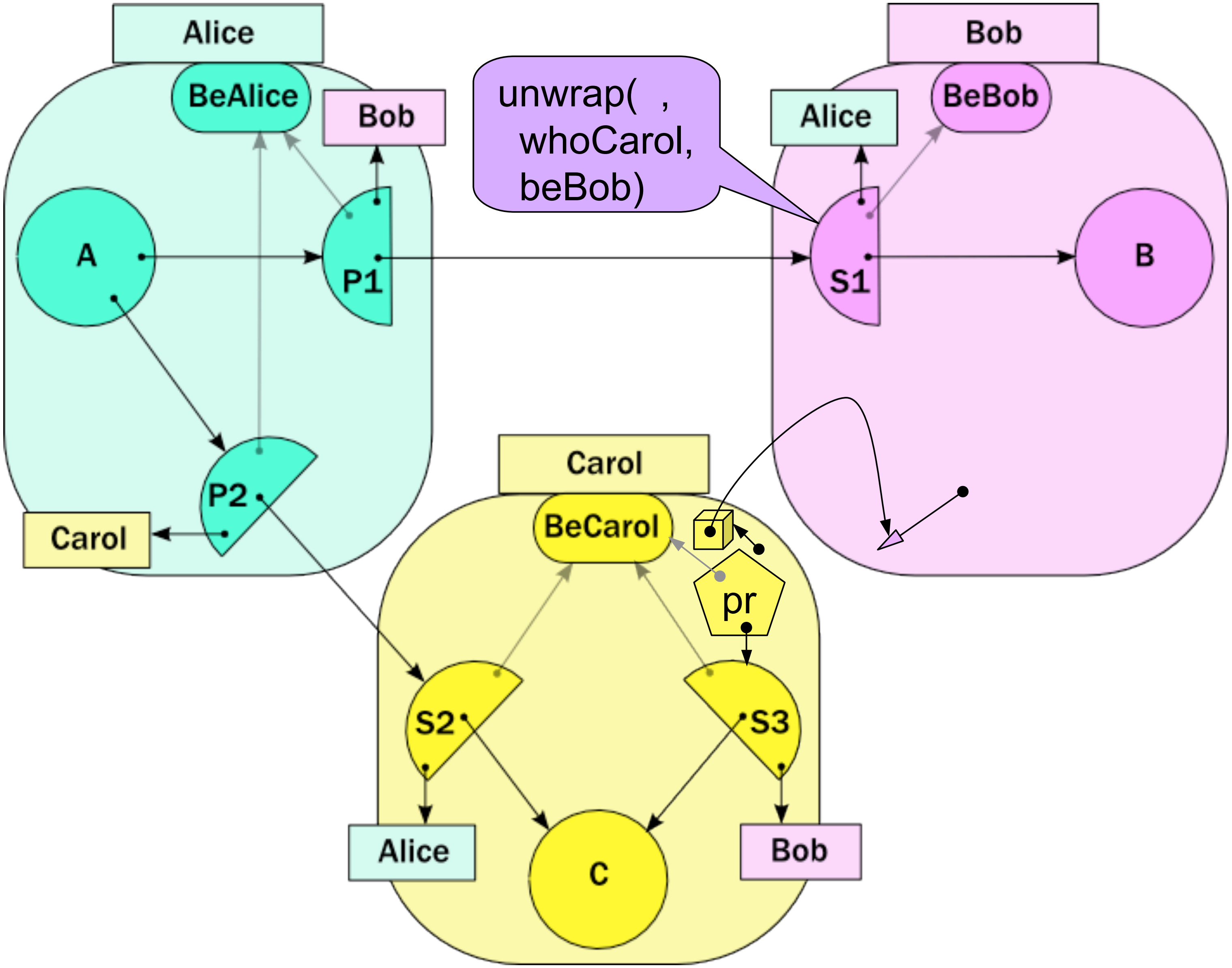

Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob


Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
Alice
BeBob
S1
B
seal( )
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

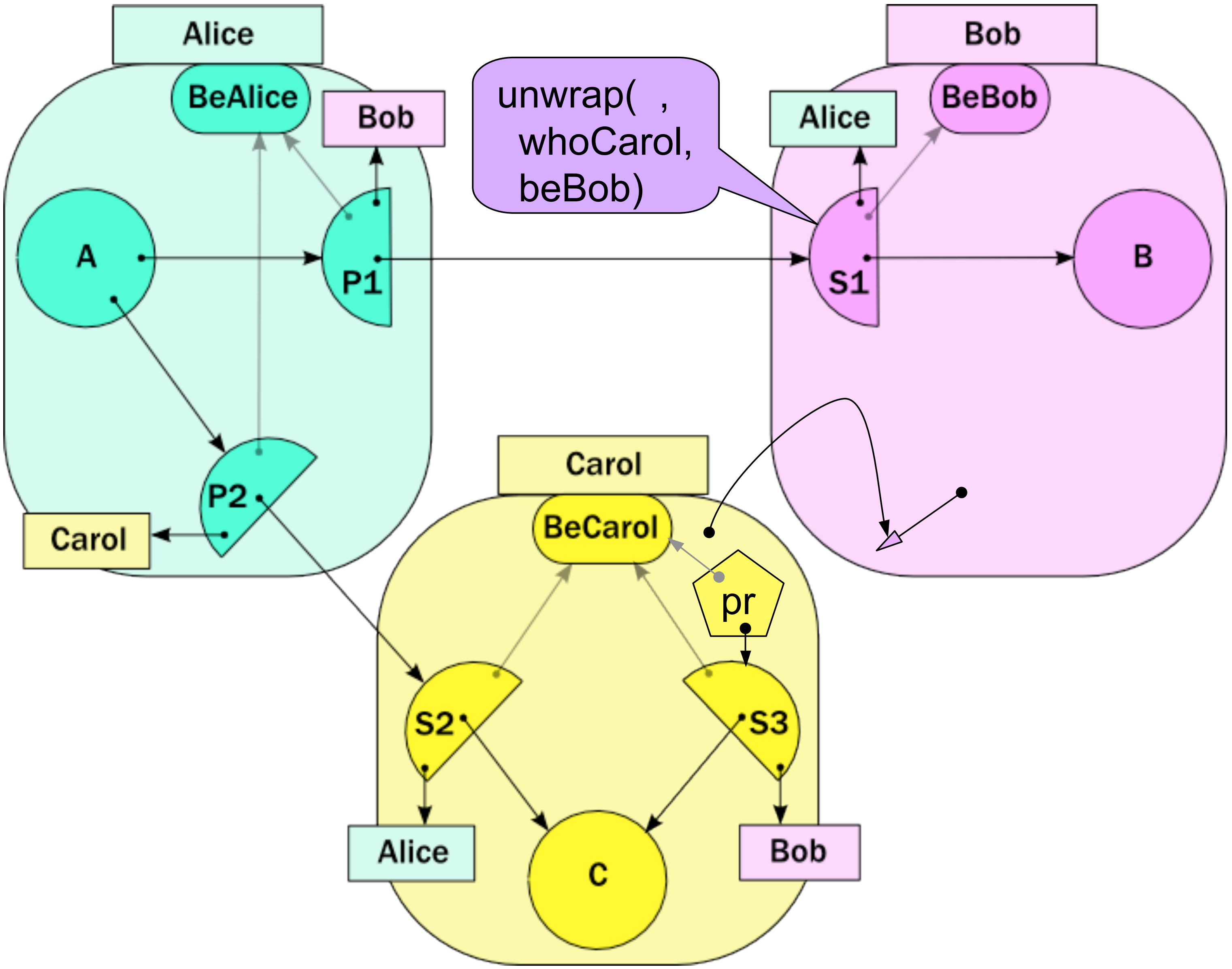


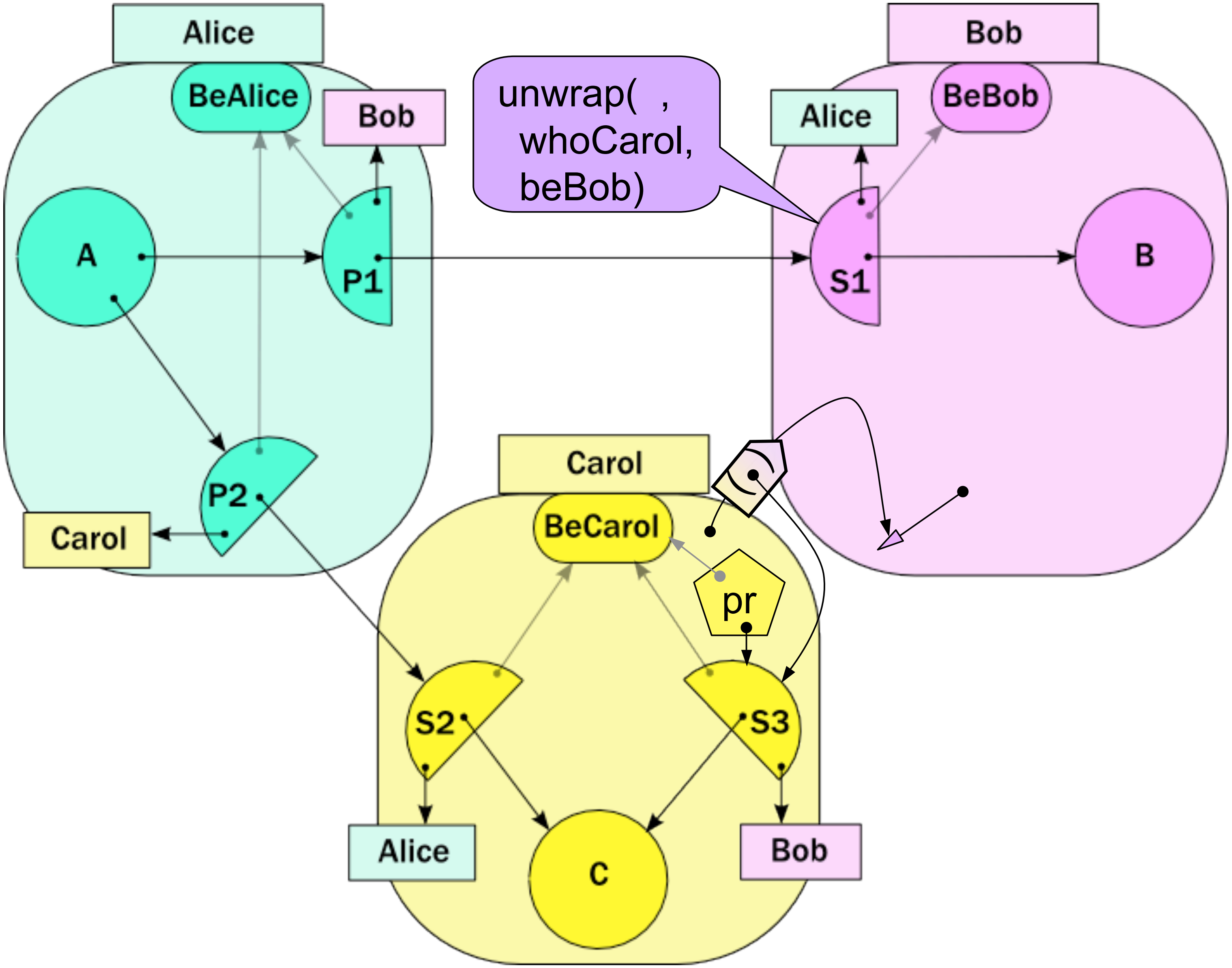
unwrap(,
whoCarol,
beBob)

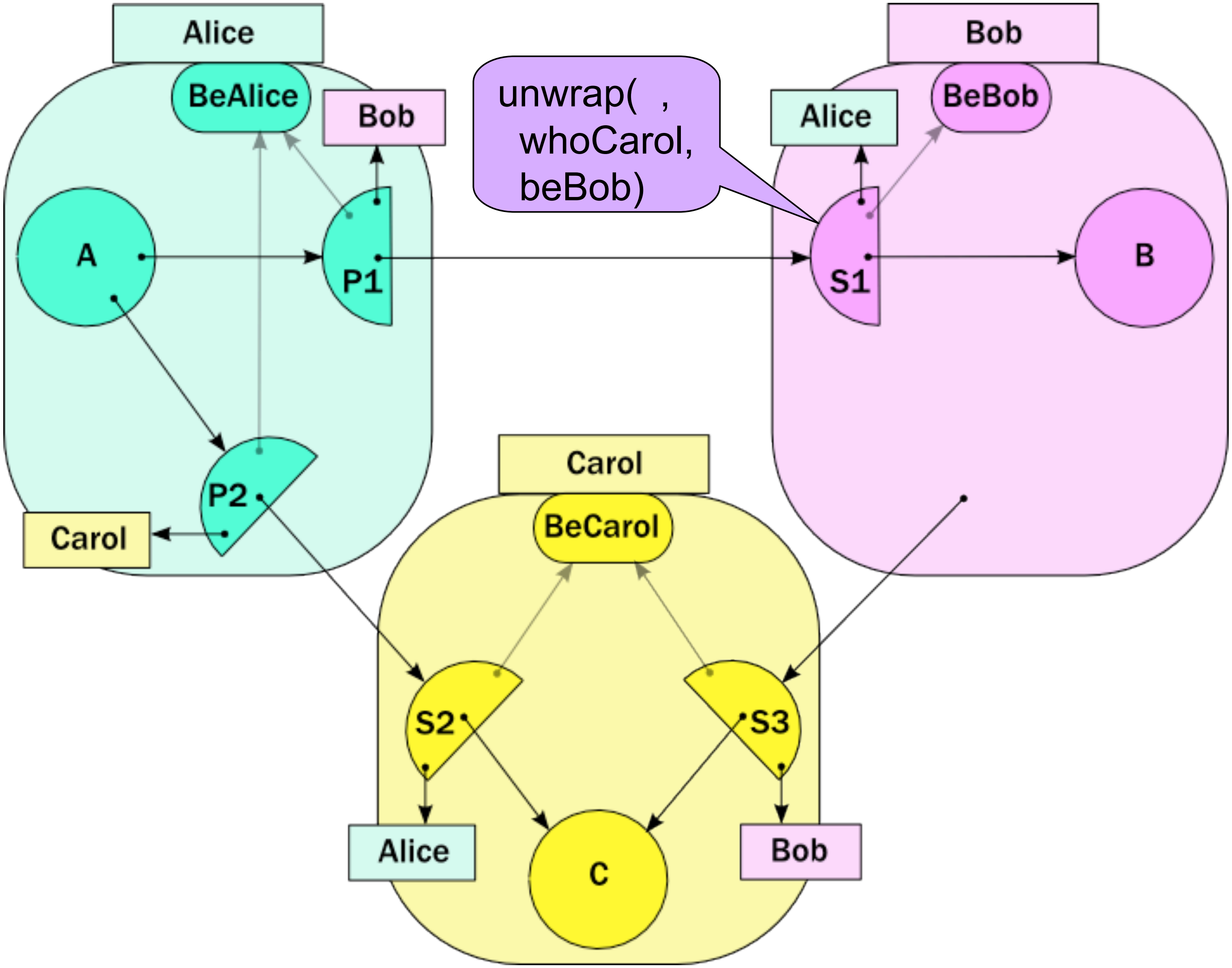

Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

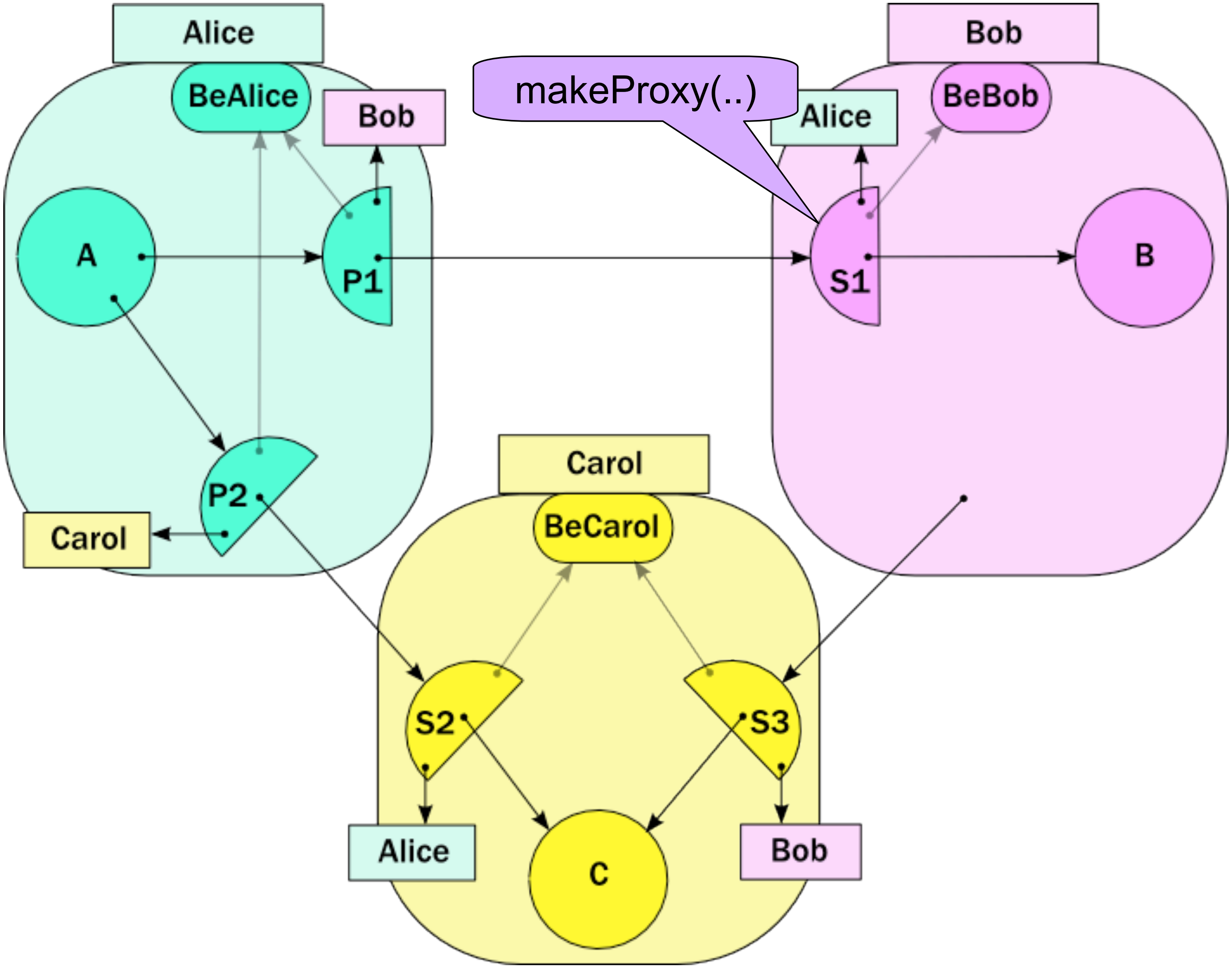


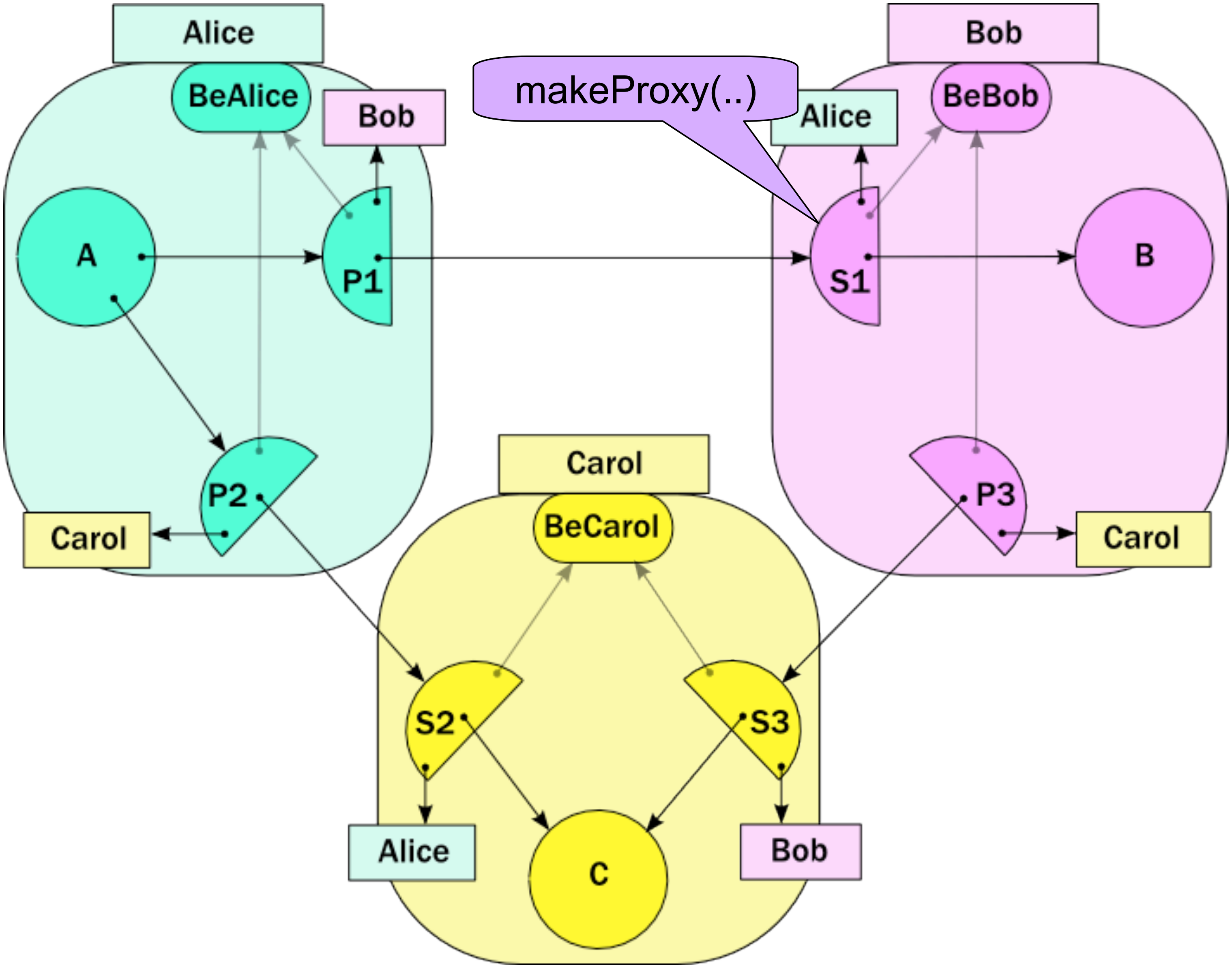
Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
Alice
BeBob
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

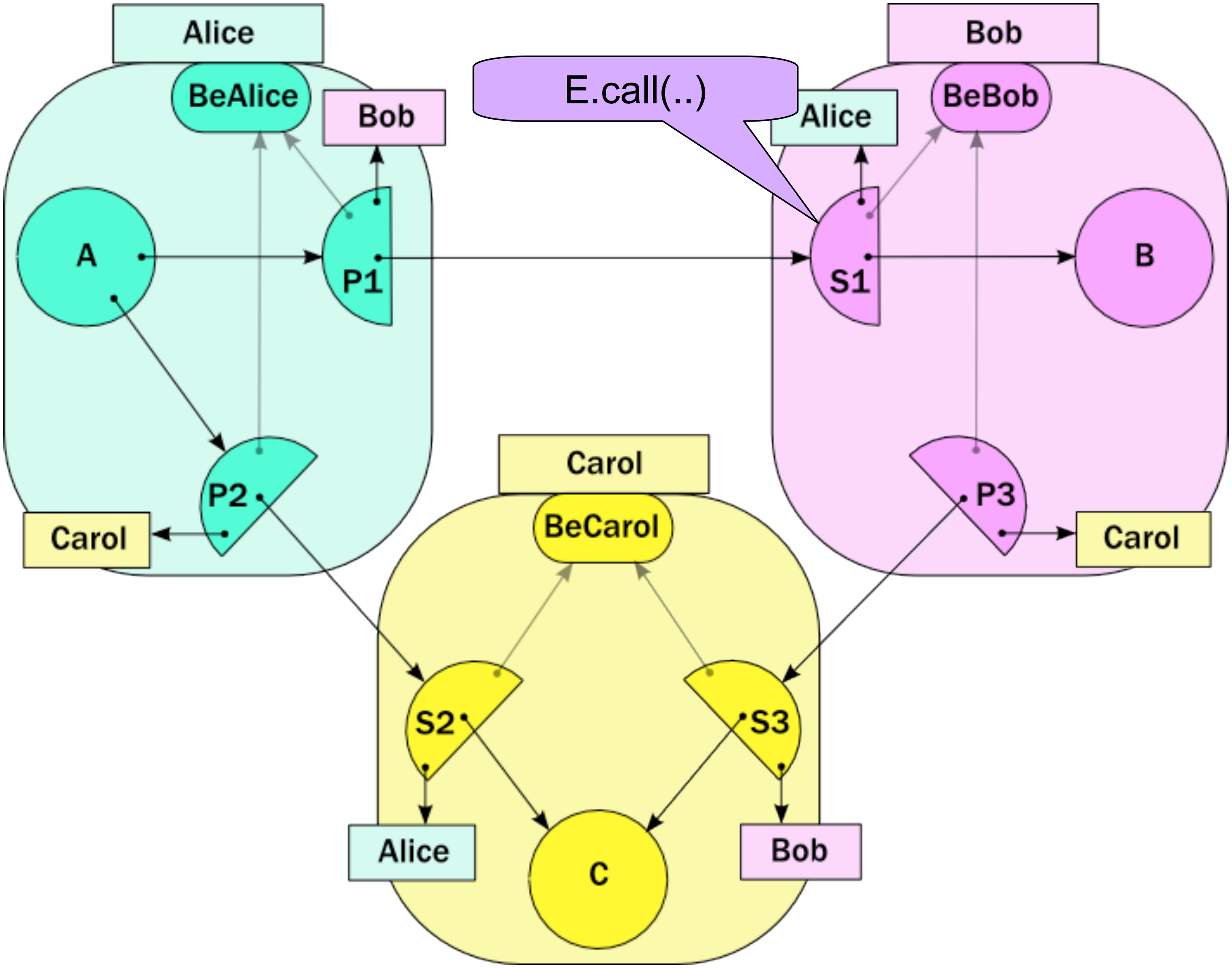

Alice
BeAlice
Bob
A
P1
P2
Carol
unwrap(,
whoCarol,
beBob)
Bob
BeBob
Alice
S1
B
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

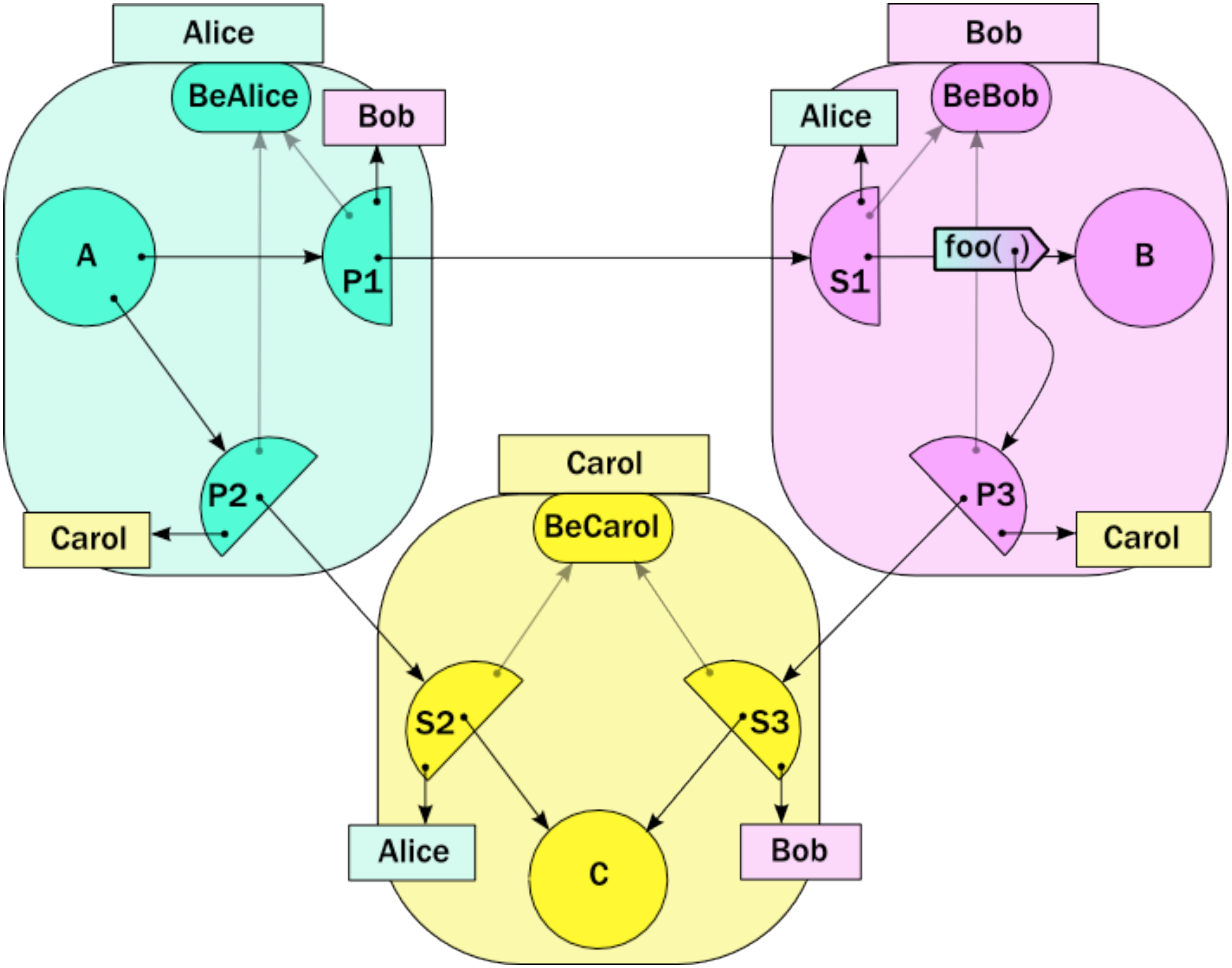

Alice
BeAlice
Bob
A
P1
P2
Carol
Bob
BeBob
Alice
S1
B
unwrap(,
whoCarol,
beBob)
Carol
BeCarol
pr
S2
S3
Alice
C
Bob

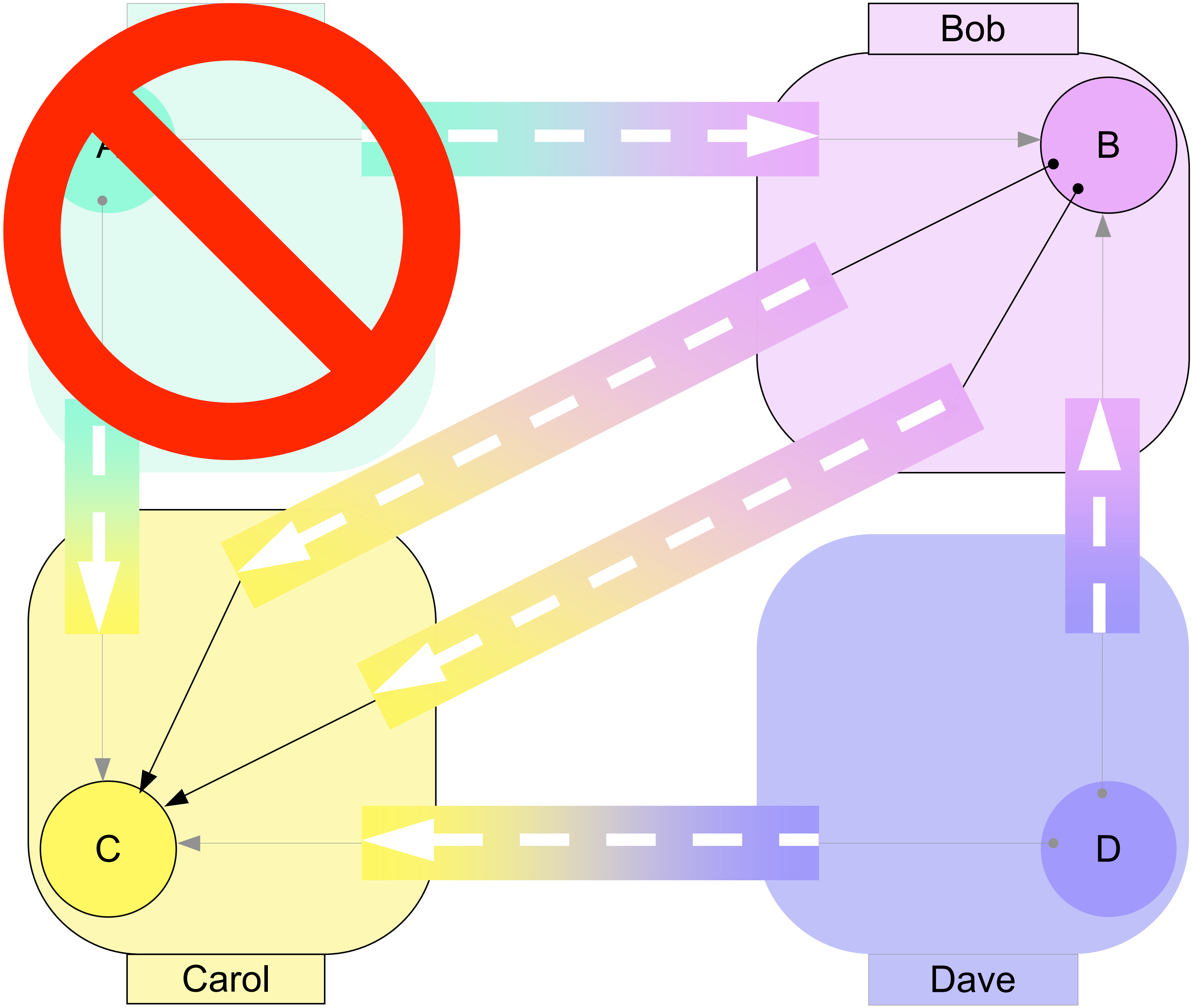

unwrap(,
whoCarol,
beBob)


Alice
BeAlice
Bob
A
P1
P2
Carol
makeProxy(..)
Bob
Alice
BeBob
S1
B
Carol
BeCarol
S2
S3
Alice
C
Bob

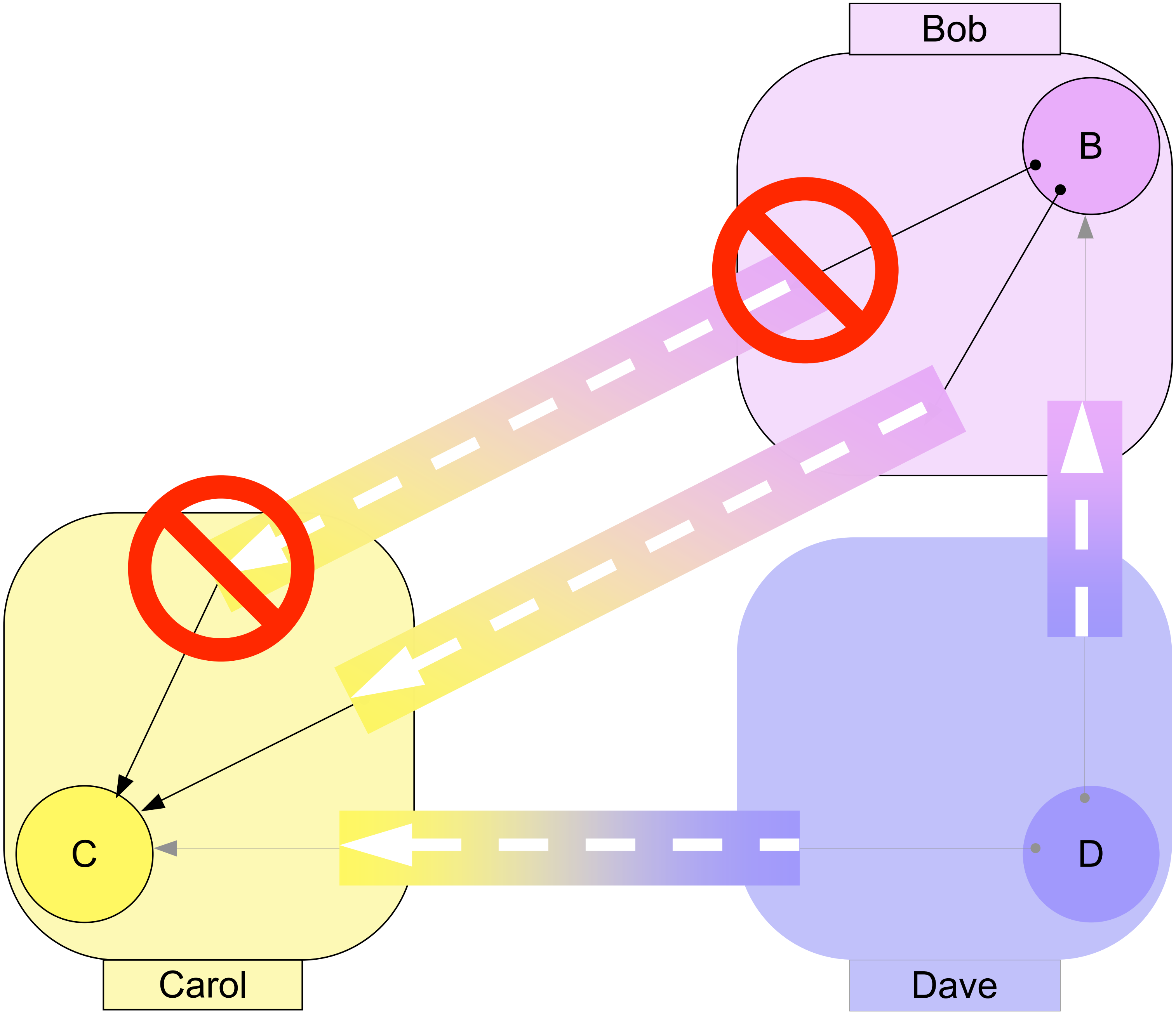

Alice
BeAlice
Bob
A
P1
P2
Carol
makeProxy(..)
Bob
Alice
BeBob
S1
B
P3
Carol
Carol
BeCarol
S2
S3
Alice
C
Bob

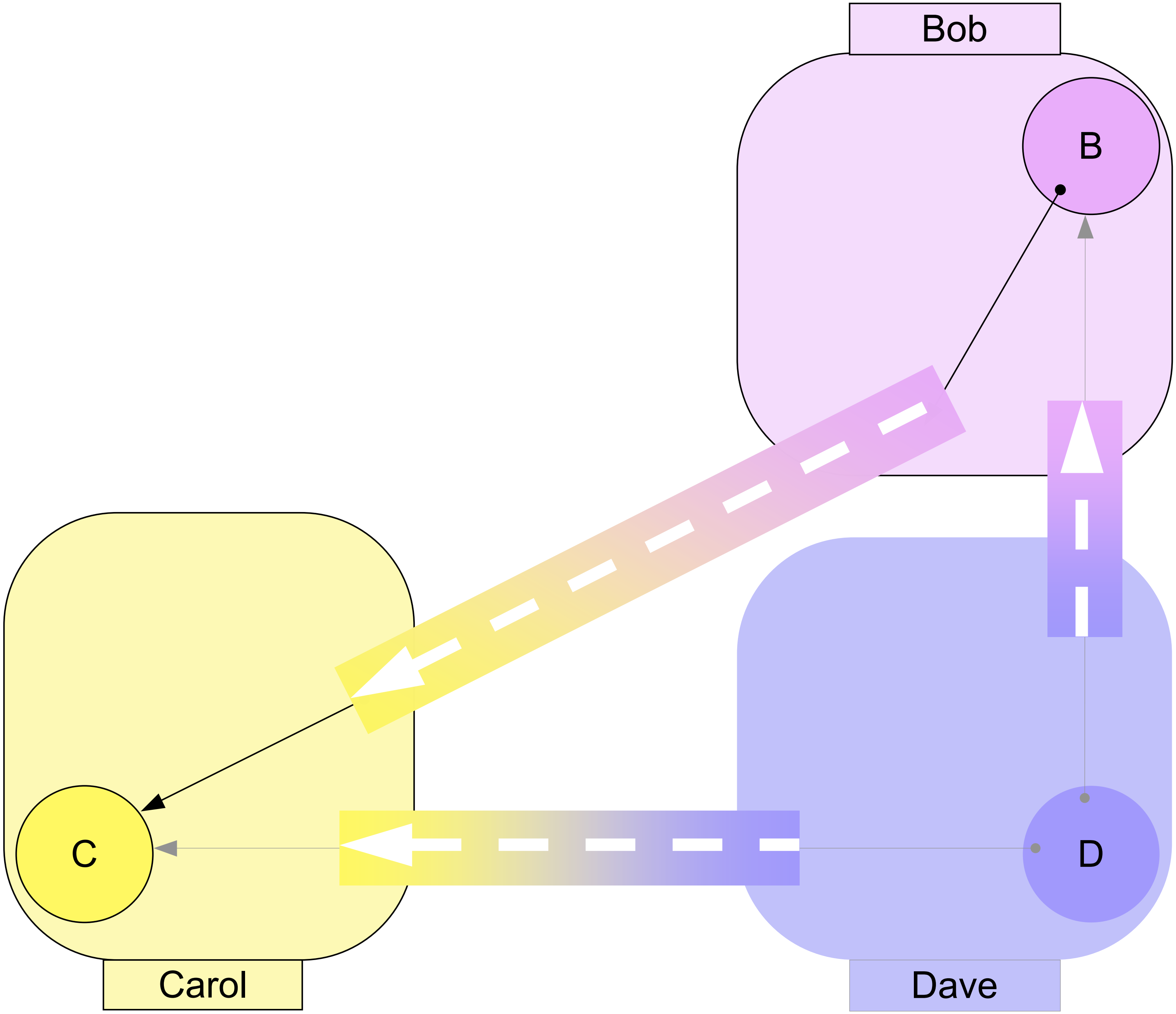

Alice
BeAlice
Bob
A
P1
P2
Carol
E.call(..)
Bob
Alice
BeBob
S1
B
P3
Carol
Carol
BeCarol
S2
S3
Alice
C
Bob


Alice
BeAlice
Bob
A
P1
P2
Carol
Bob
BeBob
Alice
S1
foo( )
B
P3
Carol
Carol
BeCarol
S2
S3
Alice
C
Bob



Bob
A
B
C
D
Carol
Dave


Bob
B
Carol
C
Dave
D


Bob
B
C
D
Carol
Dave

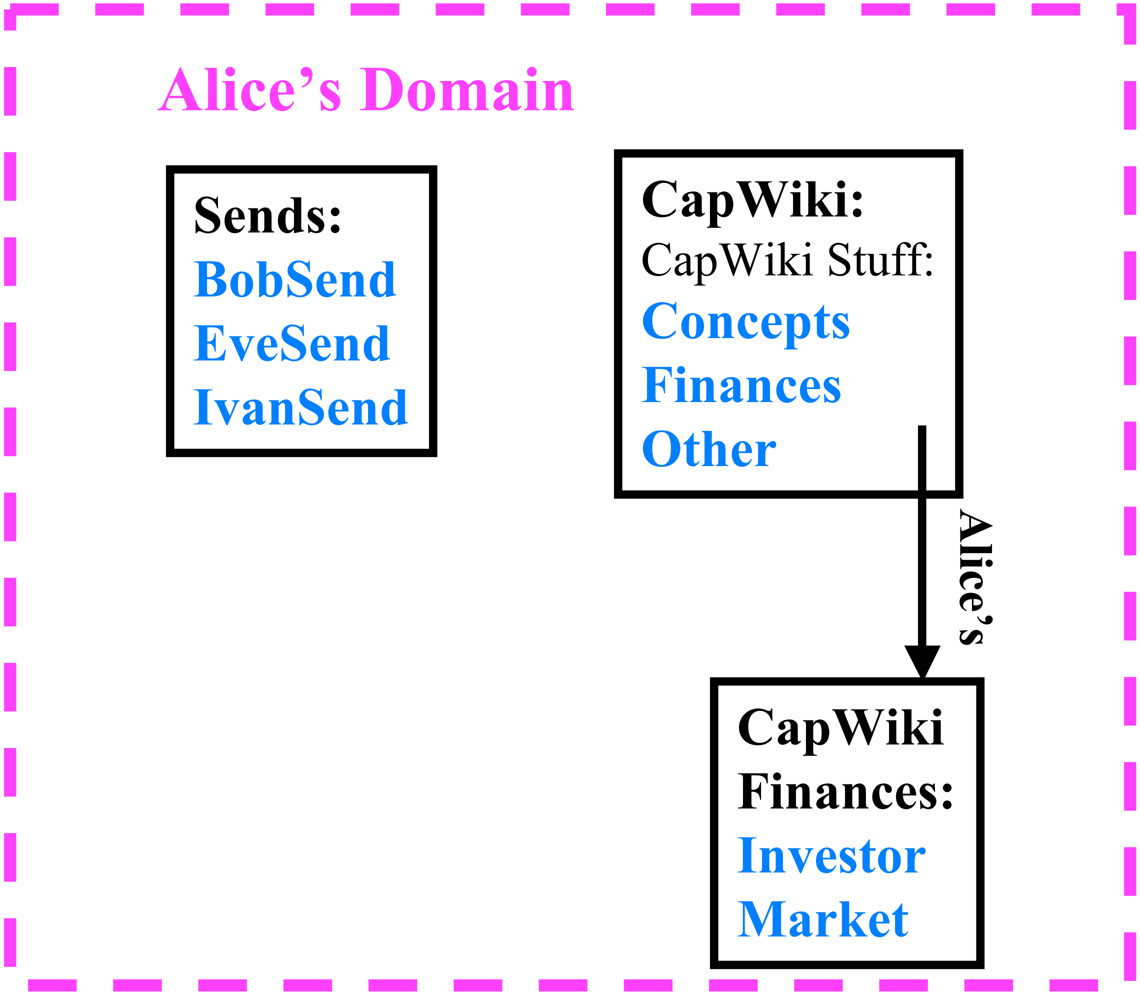
CapWiki with attribution

The Web: Good, Bad, and Ugly:

1. Good: Internet hypertext, wonderful!
2. Bad: Username/passwords for every site that has any sort of access control.
3. Ugly: Hard to share limited access to network objects. Hard to combine network objects with access restrictions.

Alice’s Domain

Sends:
BobSend
EveSend
IvanSend



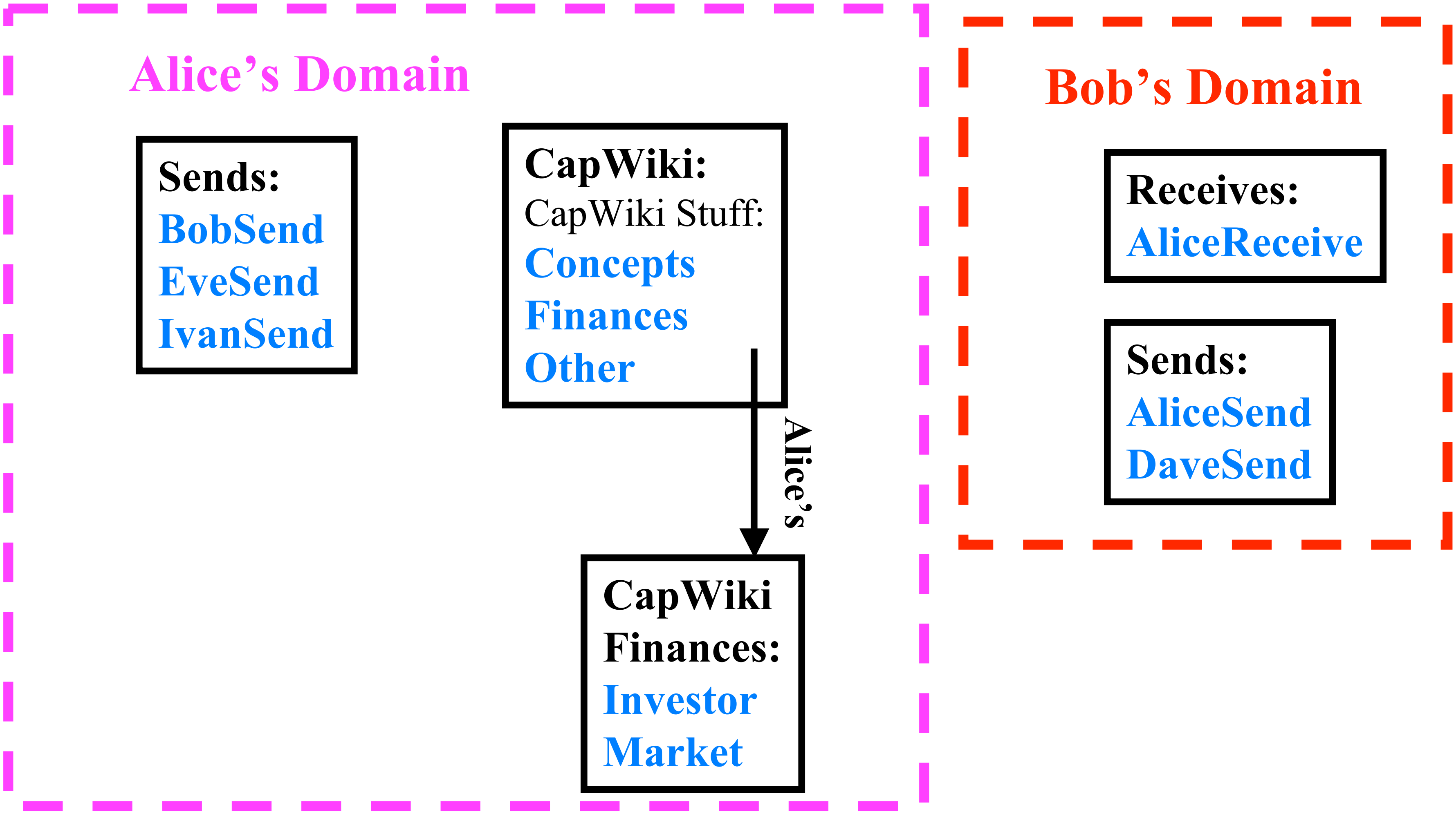
Alice’s Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice’s

CapWiki Finances:
Investor
Market



Alice's Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

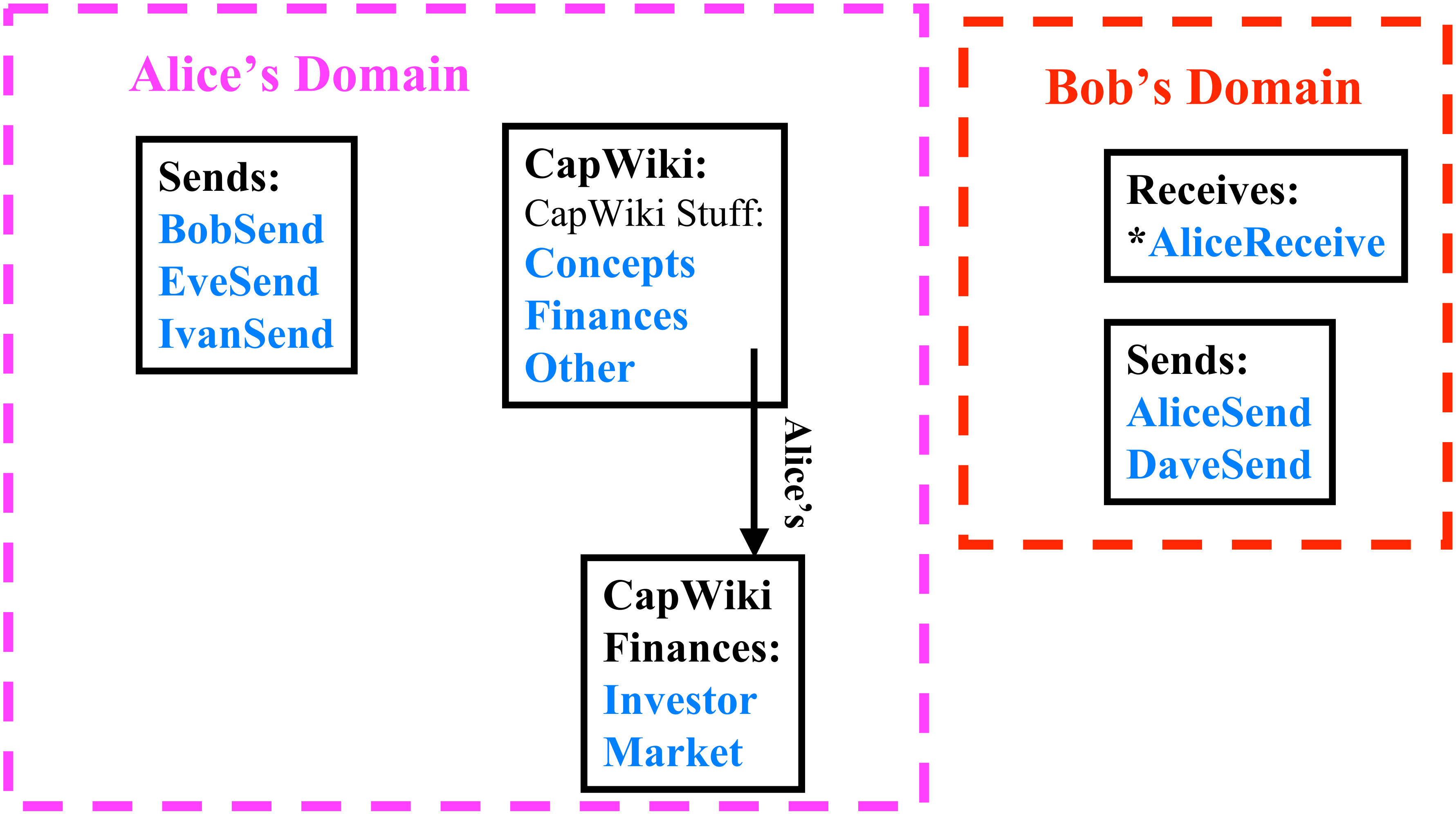
Alice's

CapWiki Finances:
Investor
Market

Bob's Domain

Receives:
AliceReceive

Sends:
AliceSend
DaveSend



Alice's Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

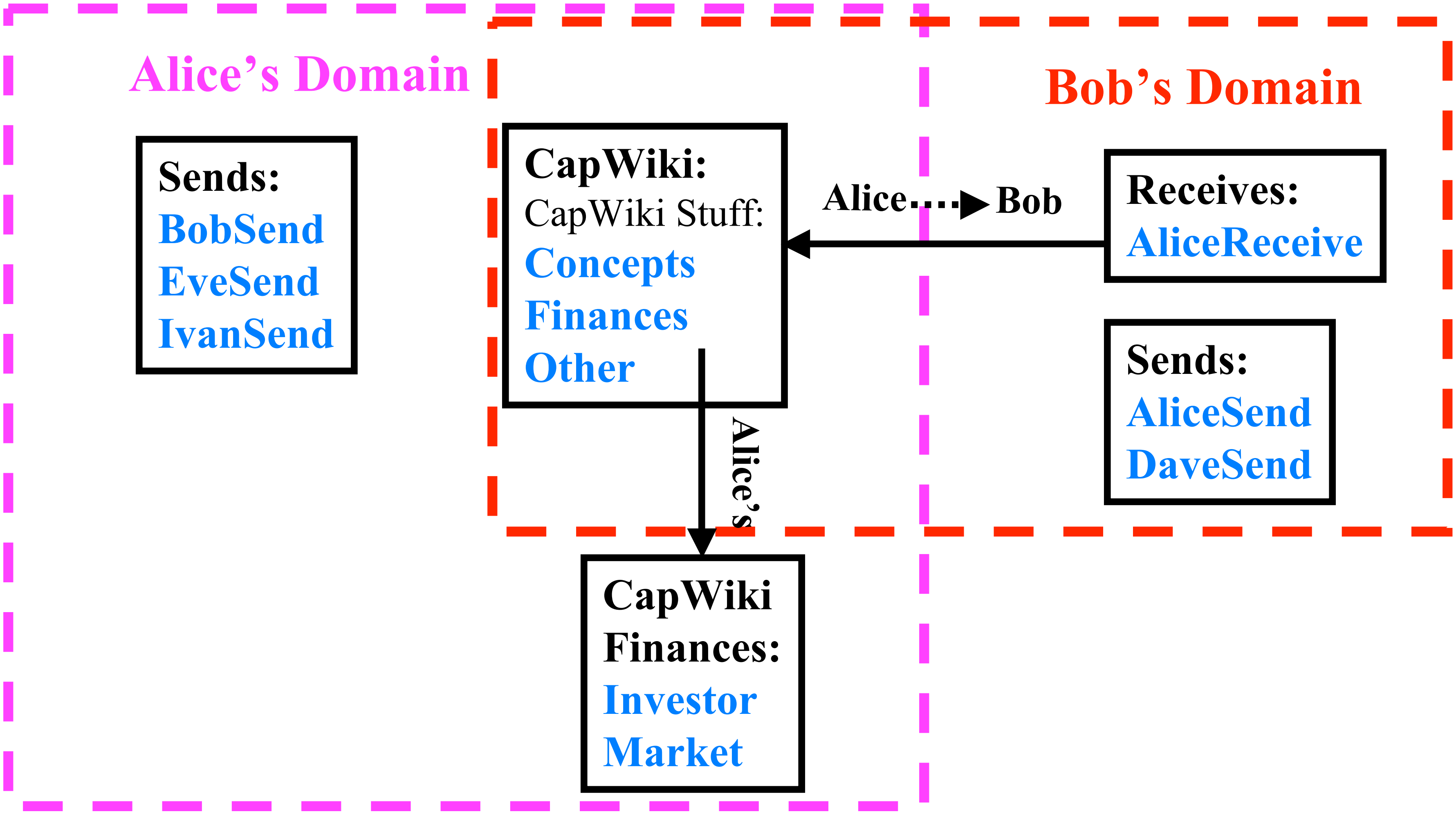
Alice's

CapWiki
Finances:
Investor
Market

Bob's Domain

Receives:
*AliceReceive

Sends:
AliceSend
DaveSend



Alice’s Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice····▶ Bob

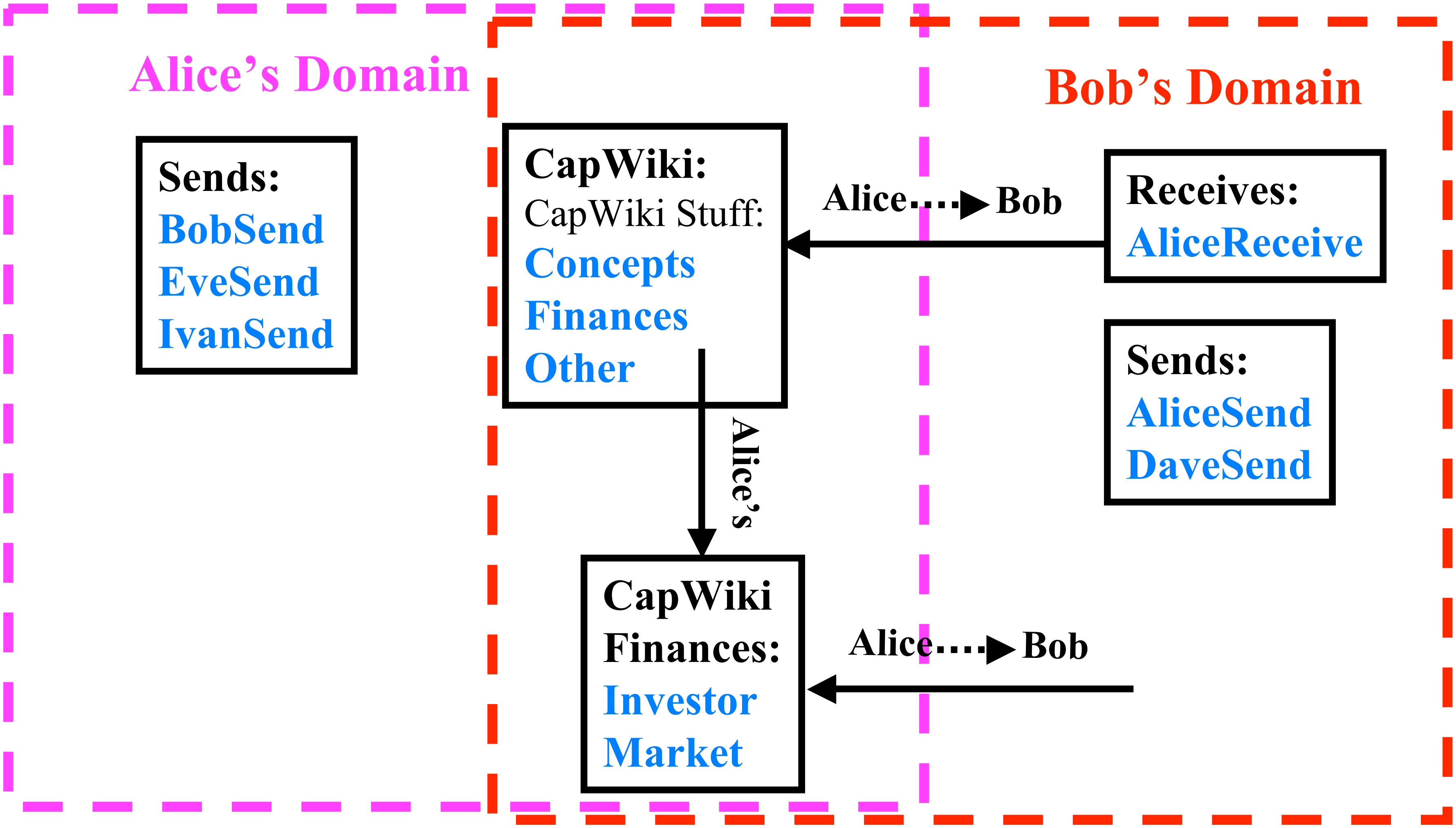
Bob’s Domain

Receives:
AliceReceive

Sends:
AliceSend
DaveSend

Alice’s

CapWiki
Finances:
Investor
Market



Alice's Domain

Bob's Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice's

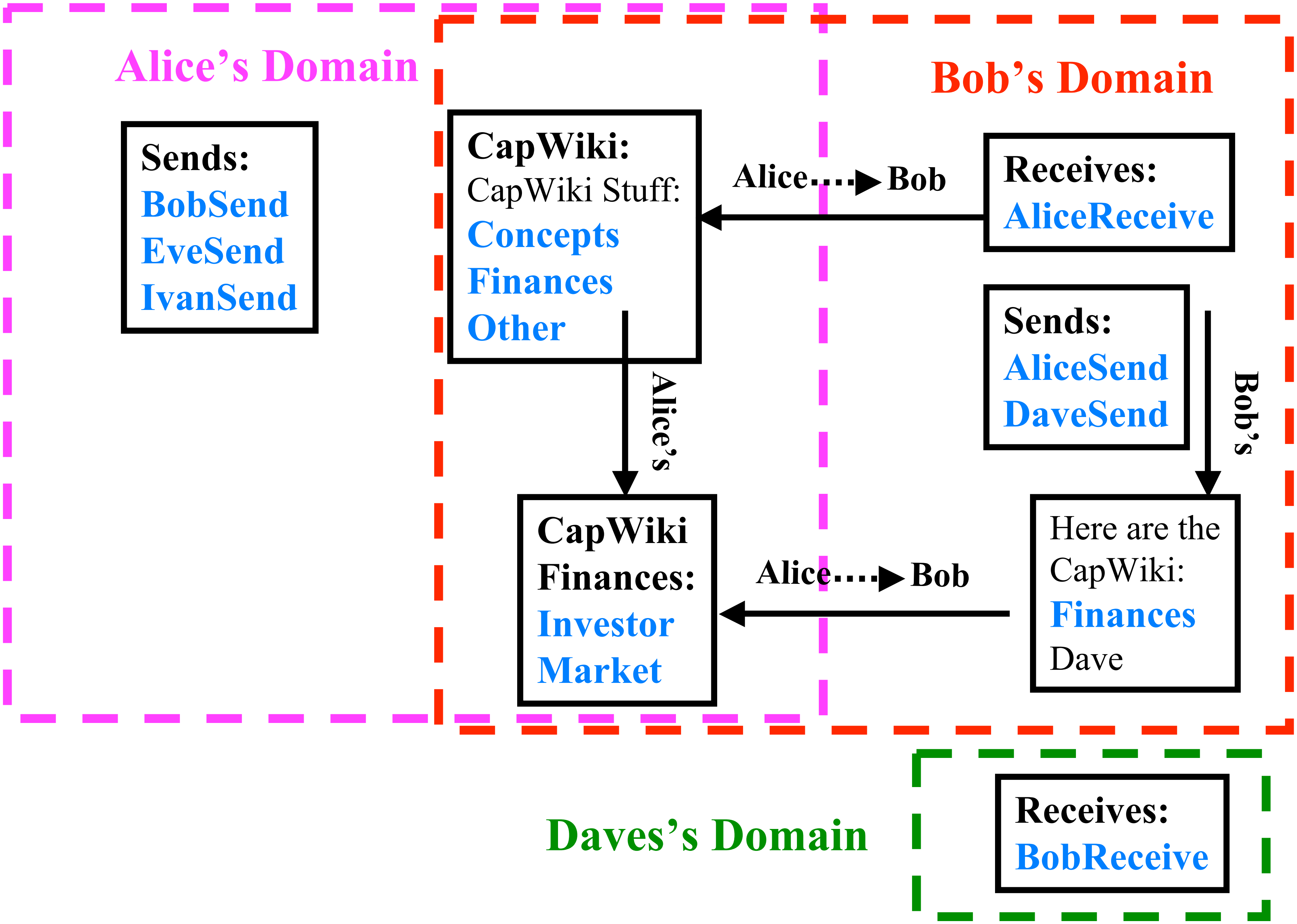
CapWiki
Finances:
Investor
Market

Alice····▶ Bob

Receives:
AliceReceive

Sends:
AliceSend
DaveSend

Alice····▶ Bob



Alice's Domain

Sends:
BobSend
EveSend
IvanSend

Bob's Domain

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice····▶ Bob

Receives:
AliceReceive

Sends:
AliceSend
DaveSend

Alice's

Bob's

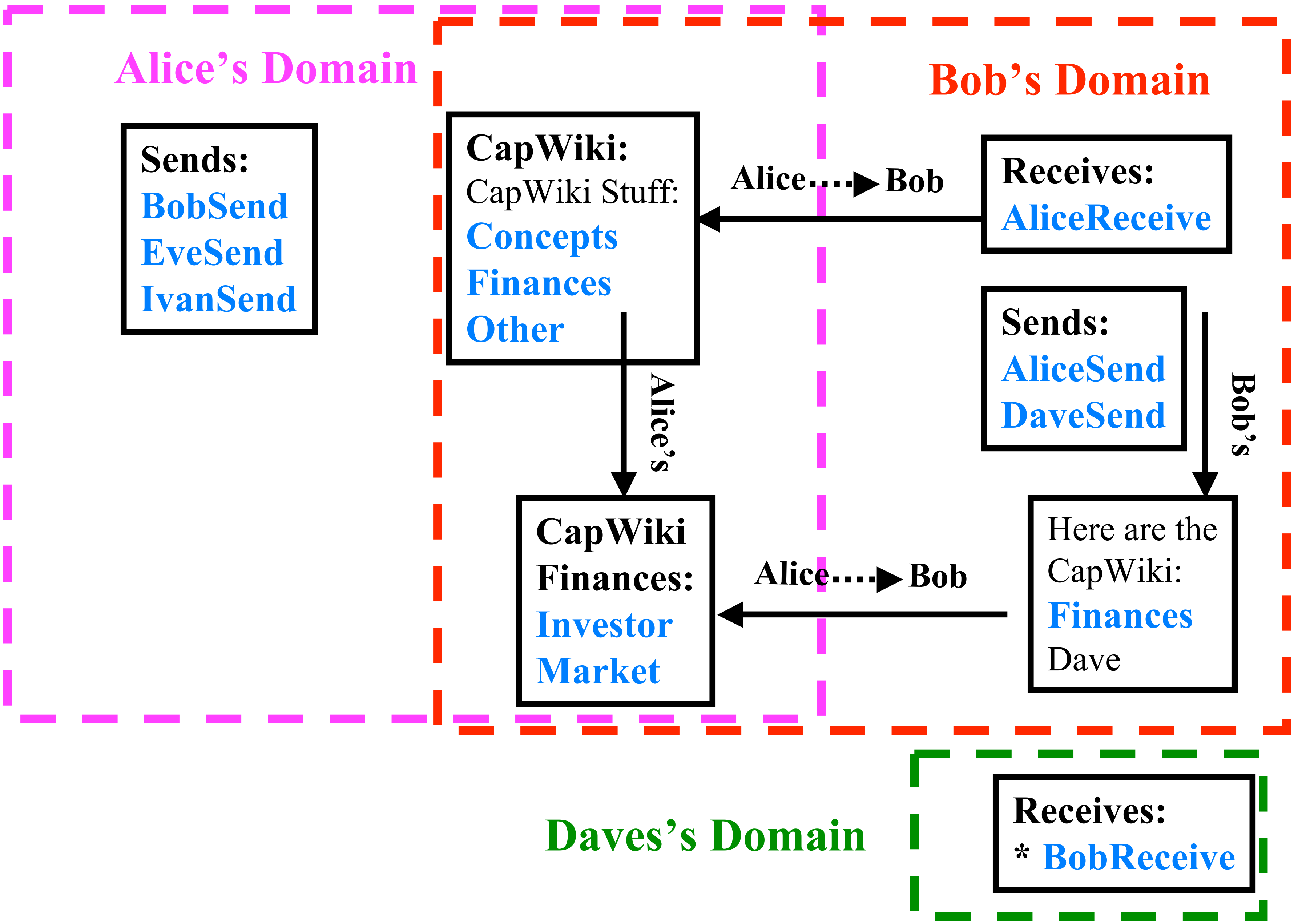
CapWiki
Finances:
Investor
Market

Alice····▶ Bob

Here are the
CapWiki:
Finances
Dave

Daves's Domain

Receives:
BobReceive



Alice’s Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice’s

CapWiki
Finances:
Investor
Market

Bob’s Domain

Alice····▶ Bob

Receives:
AliceReceive

Sends:
AliceSend
DaveSend

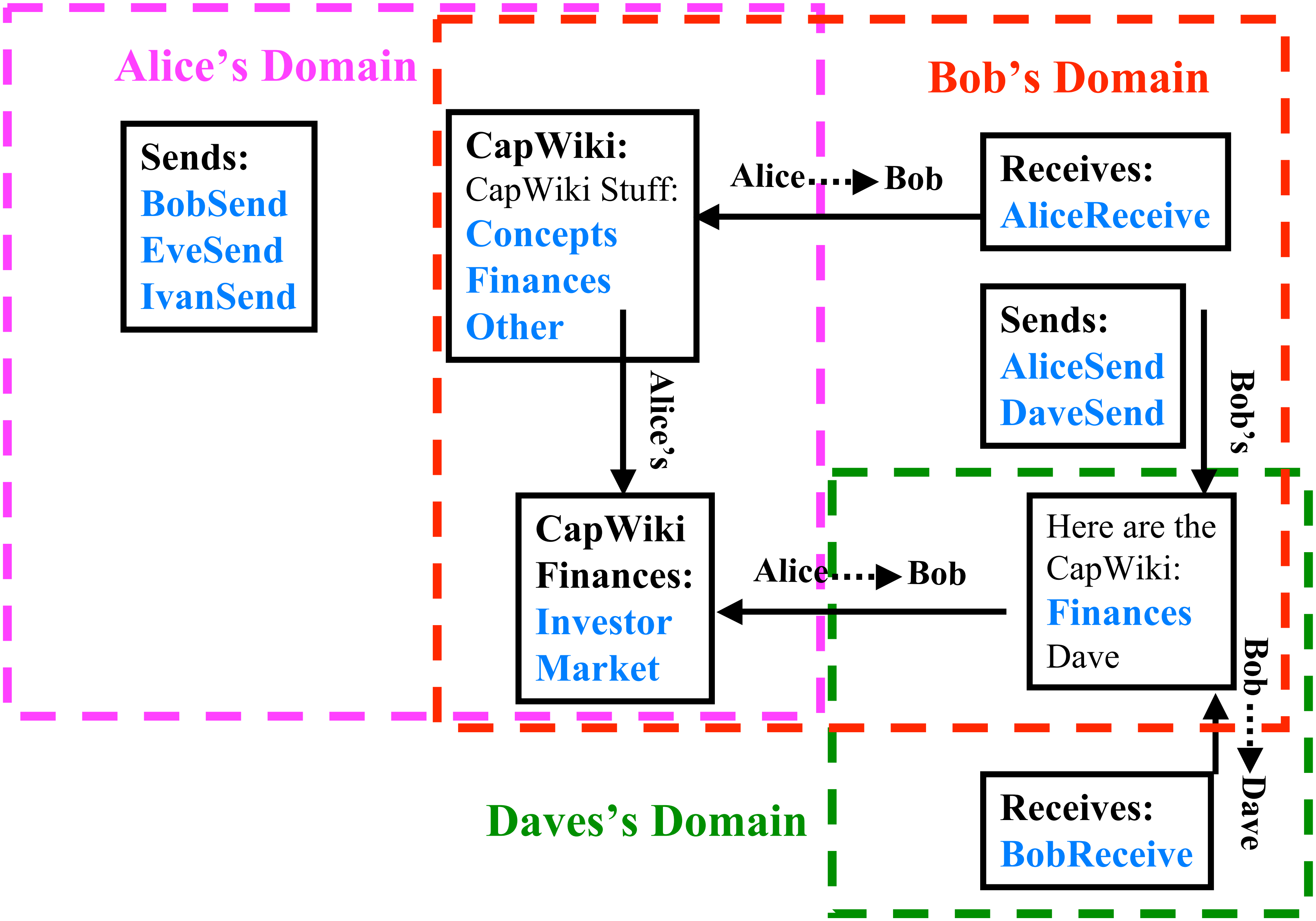
Bob’s

Here are the
CapWiki:
Finances
Dave

Alice····▶ Bob

Daves’s Domain

Receives:
* BobReceive



Alice’s Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice’s

CapWiki
Finances:
Investor
Market

Bob’s Domain

Alice····▶ Bob

Receives:
AliceReceive

Sends:
AliceSend
DaveSend

Bob’s

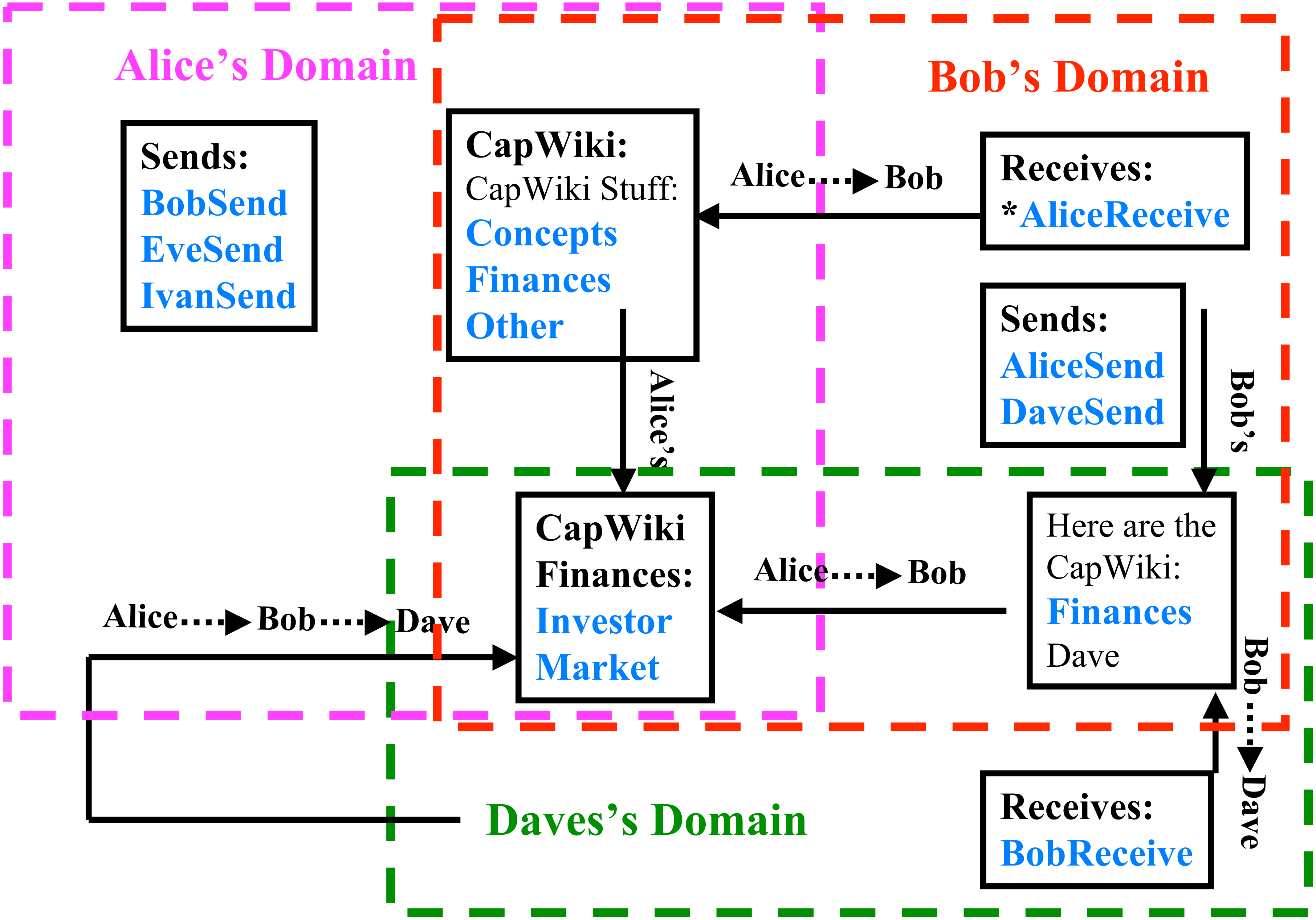
Here are the
CapWiki:
Finances
Dave

Alice····▶ Bob

Bob····▶ Dave

Receives:
BobReceive

Daves’s Domain



Alice’s Domain

Sends:
BobSend
EveSend
IvanSend

CapWiki:
CapWiki Stuff:
Concepts
Finances
Other

Alice····▶Bob

Bob’s Domain

Receives:
*AliceReceive

Sends:
AliceSend
DaveSend

Alice’s

Bob’s

CapWiki
Finances:
Investor
Market

Alice····▶Bob

Here are the
CapWiki:
Finances
Dave

Alice····▶Bob····▶Dave

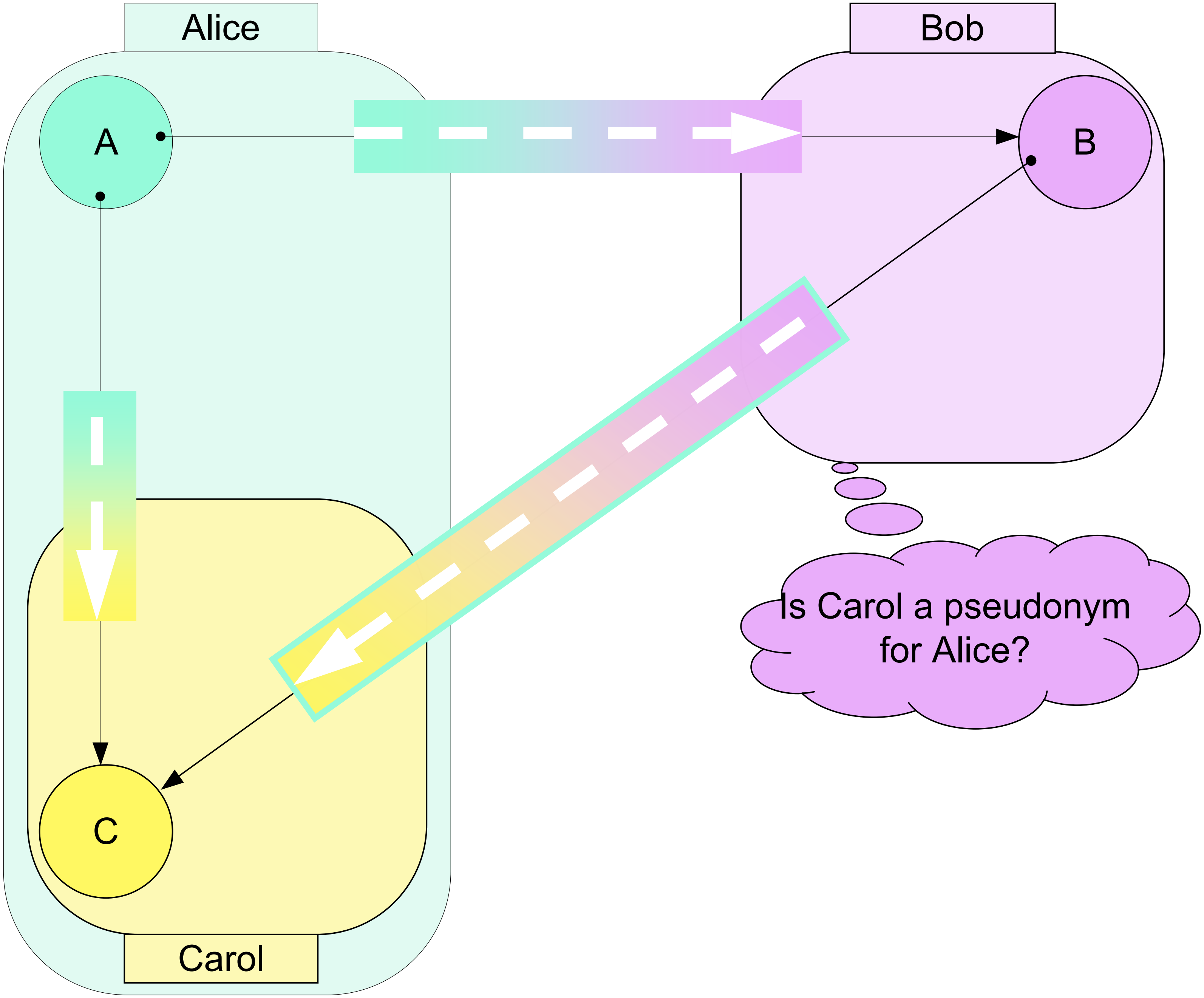
Bob····▶Dave

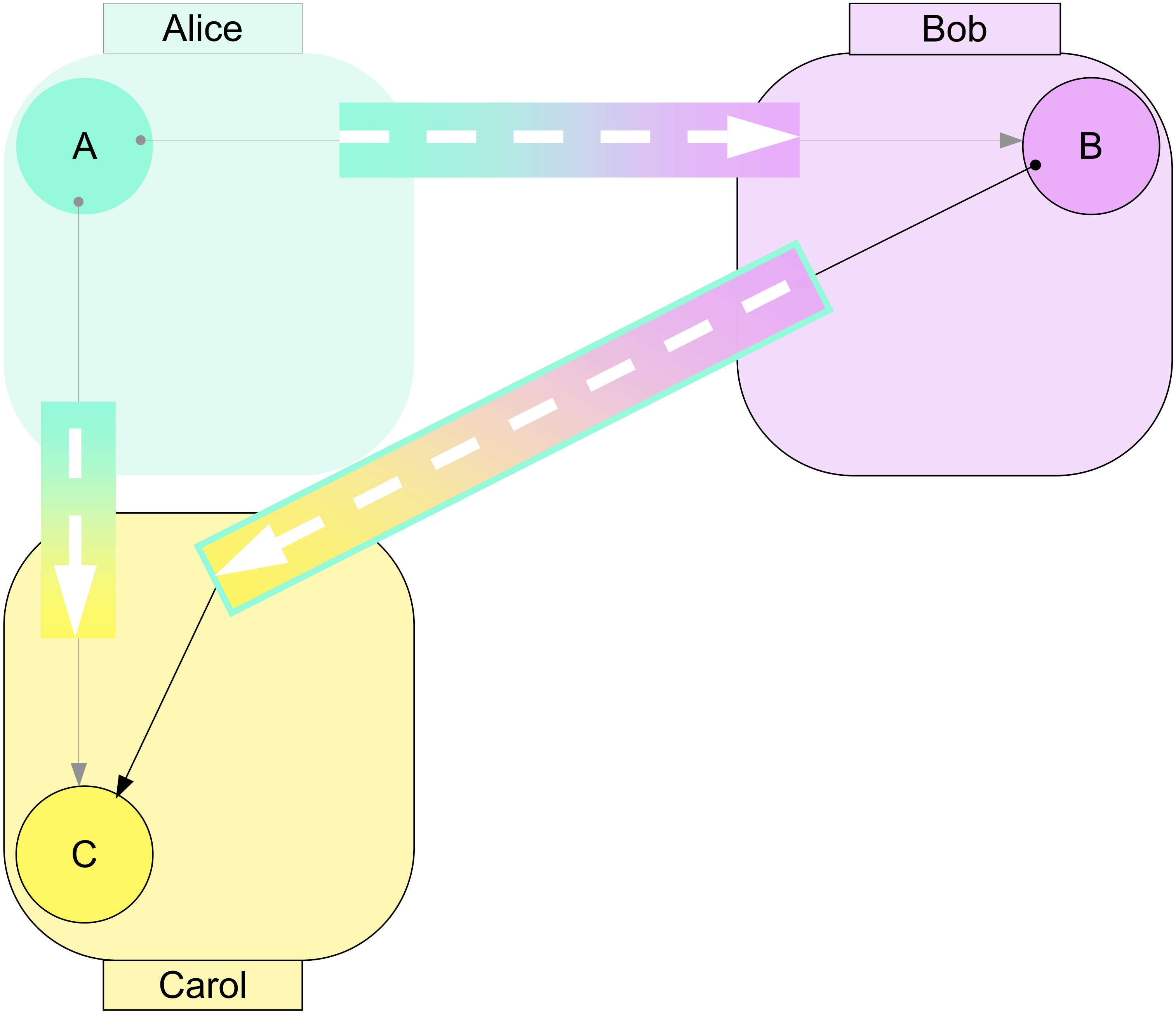
Daves’s Domain

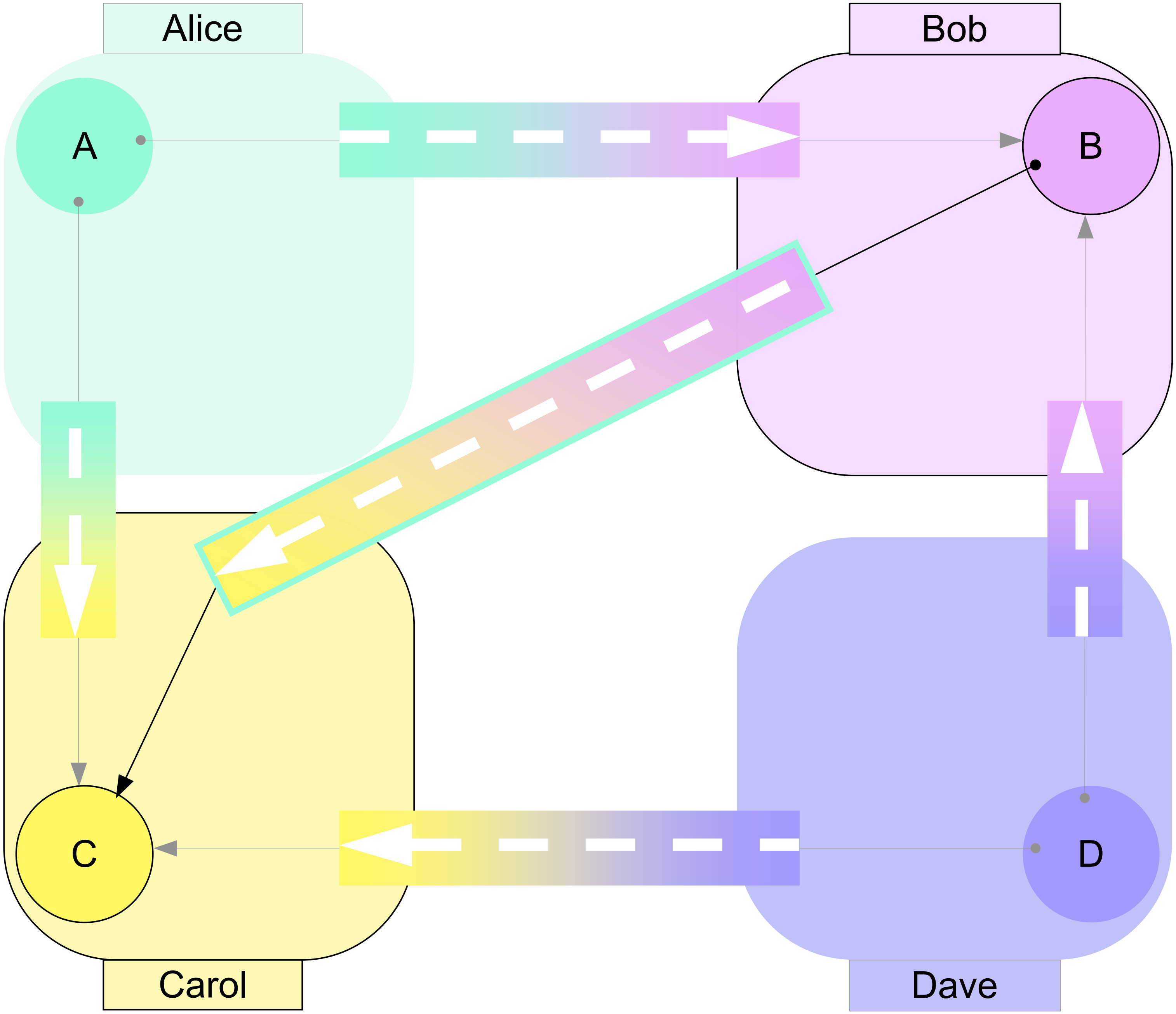
Receives:
BobReceive

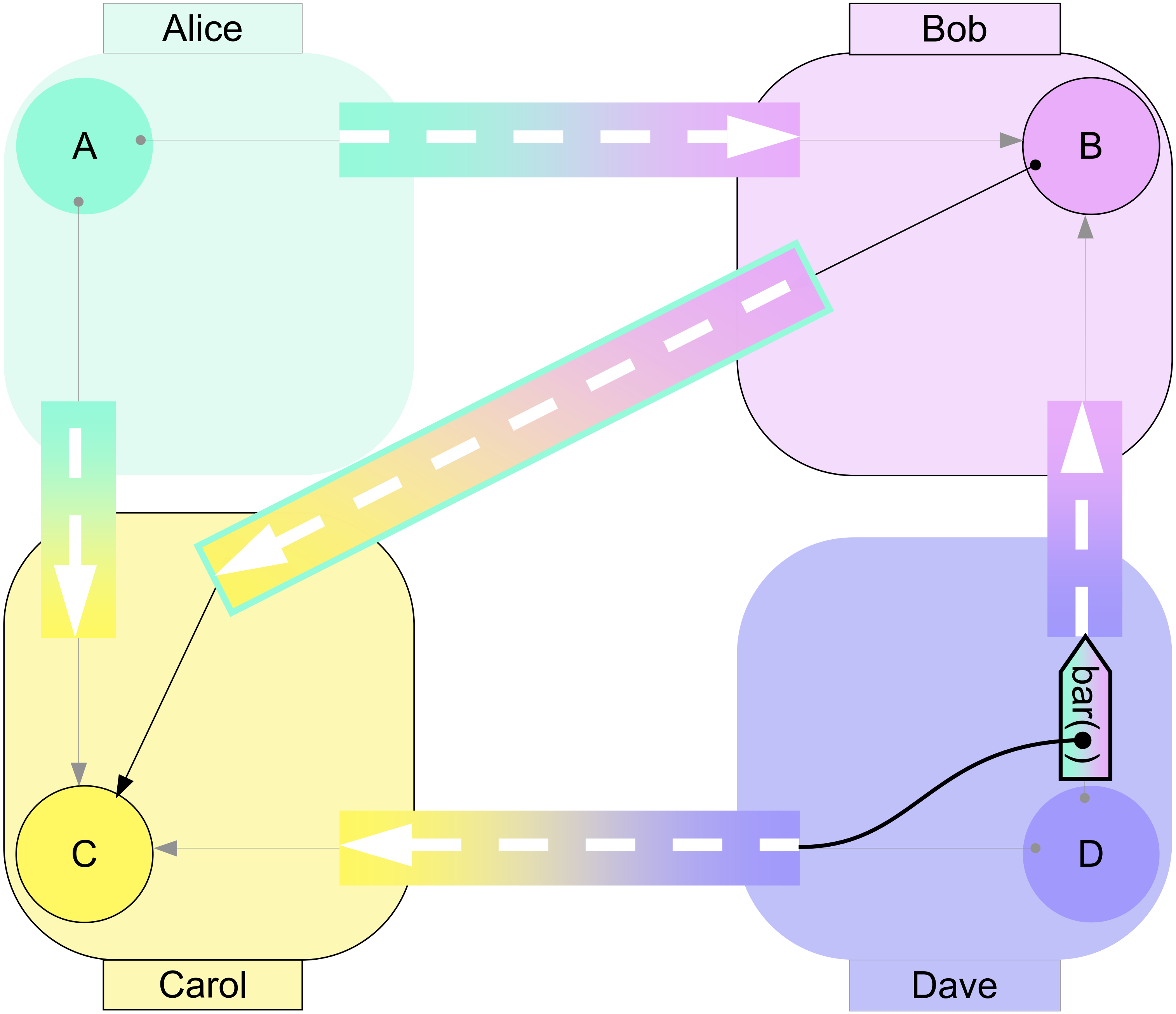
Better Web Access Control

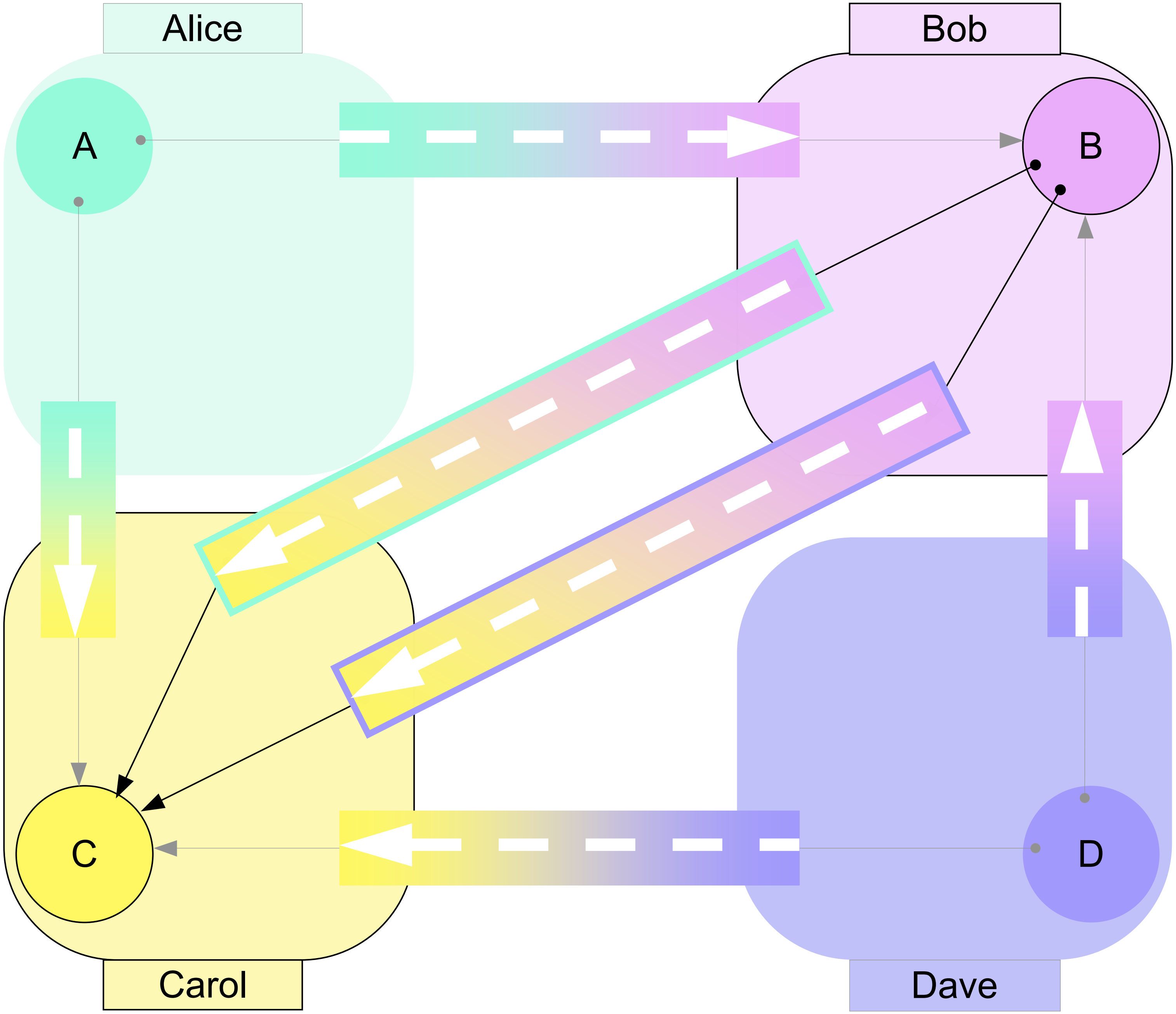
- No more passwords – Send a <me>Send to a <service>Send. They know who you are, you know who they are.
- Side benefit – SPAM resistance. Don’t like a source of SPAM, cut it off to any delegation level.
- Principle Of Least Authority (POLA) sharing that can facilitate cross site services.

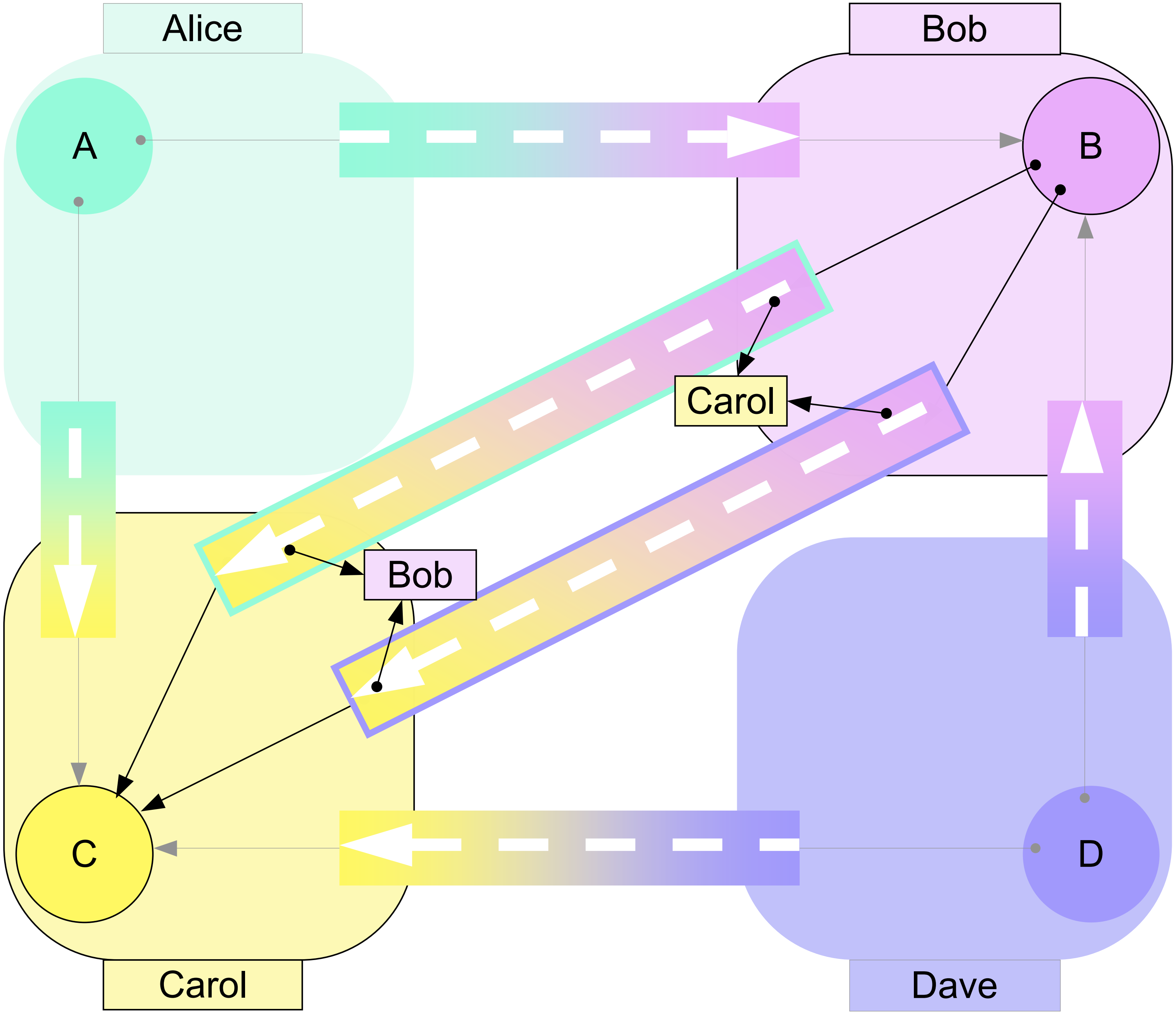

Alice
Bob
A
B
C
Carol
Is Carol a pseudonym
for Alice?


Alice
Bob
A
B
C
Carol


Alice
Bob
A
B
C
D
Carol
Dave


Alice
Bob
A
B
C
D
bar()
Carol
Dave


Alice
Bob
A
B
C
D
Carol
Dave



Alice
Bob
A
B
Carol
Bob
C
D
Carol
Dave