

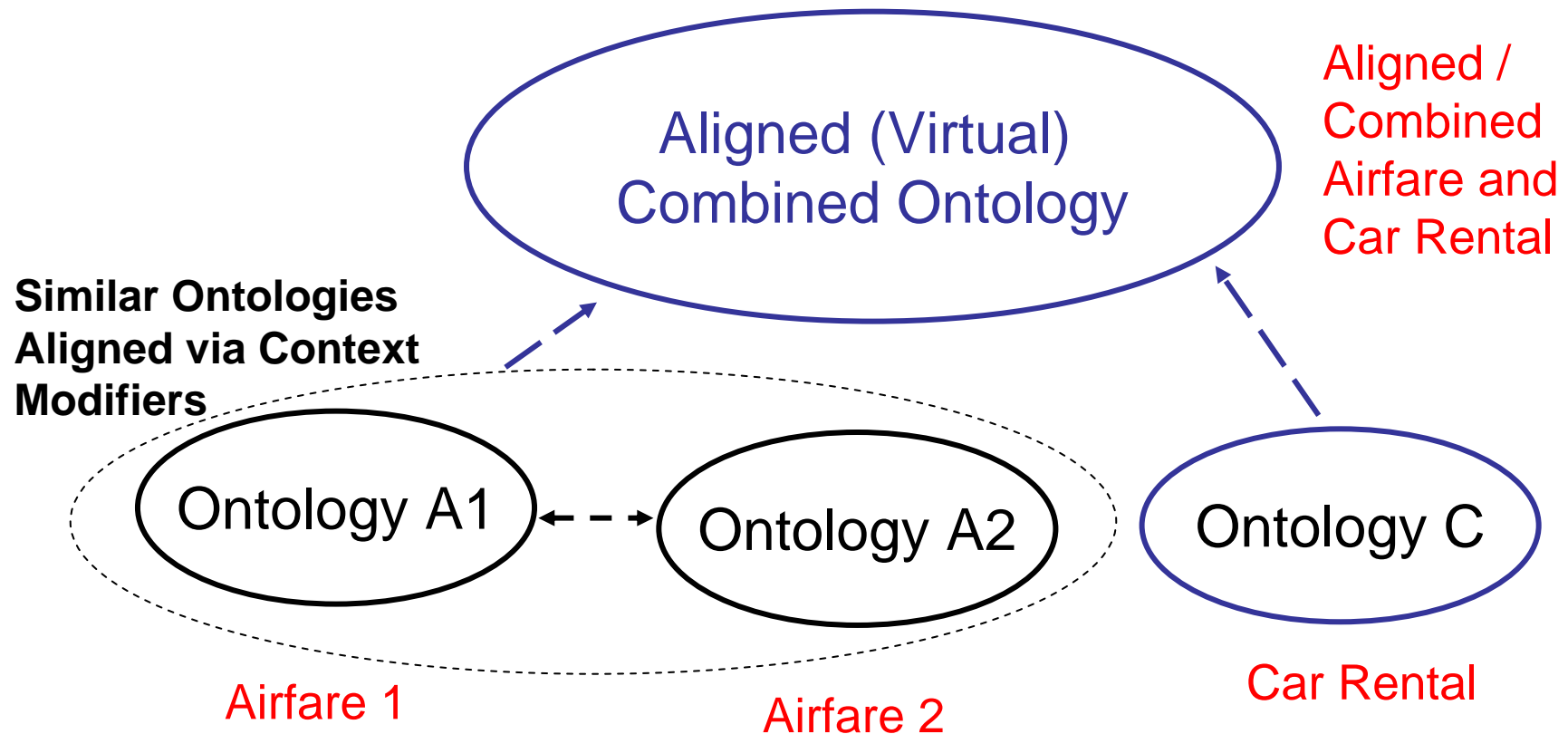
CONTEXTUAL ALIGNMENT OF ONTOLOGIES FOR SEMANTIC INTEROPERABILITY

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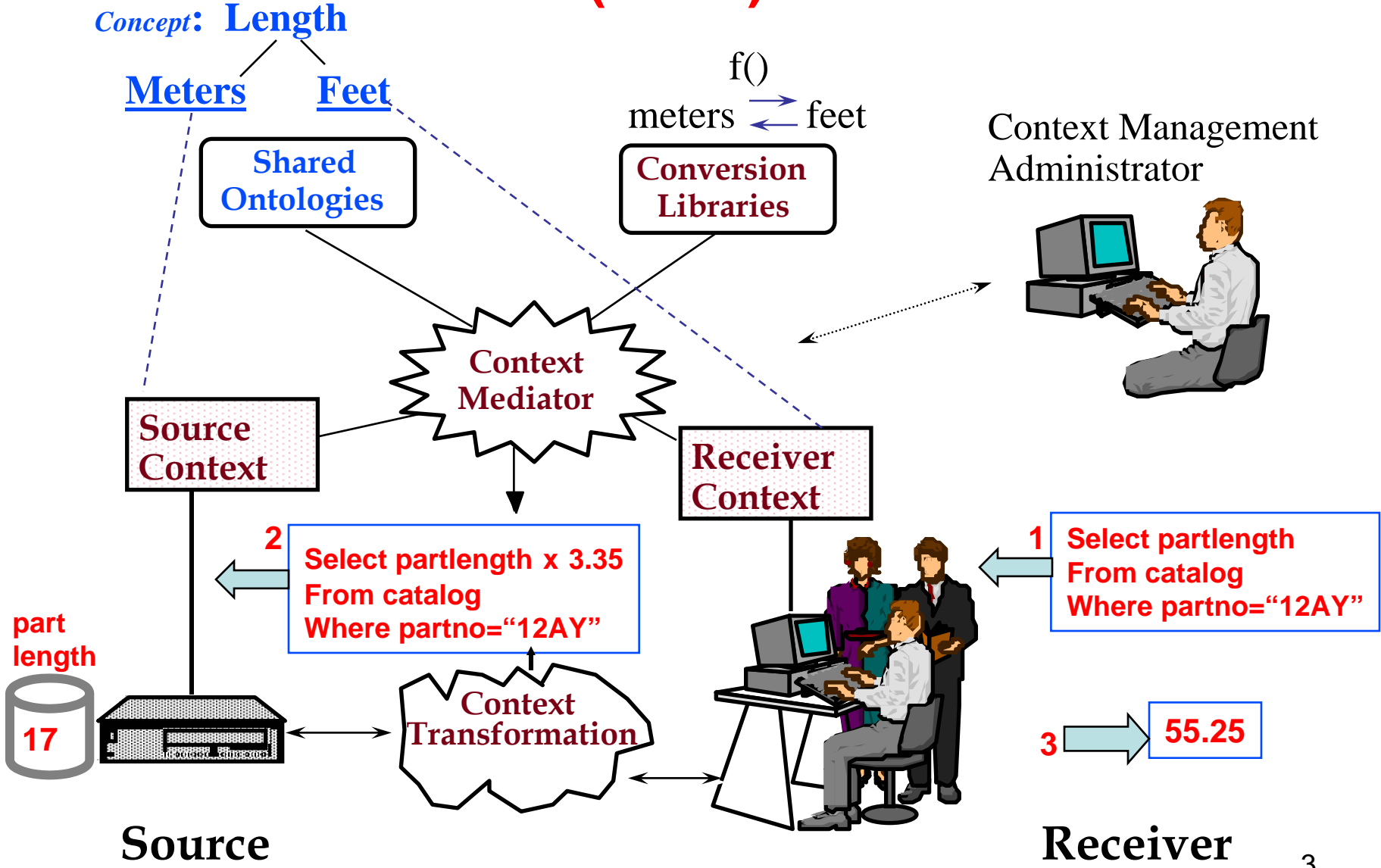
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Overview



- Need to accommodate multiple ontology views simultaneous (A1 and A2)
- Need to integrate (combine) separately created ontologies (A1/A2 with C)
- Accomplished by *contexts* and *conversion function networks*

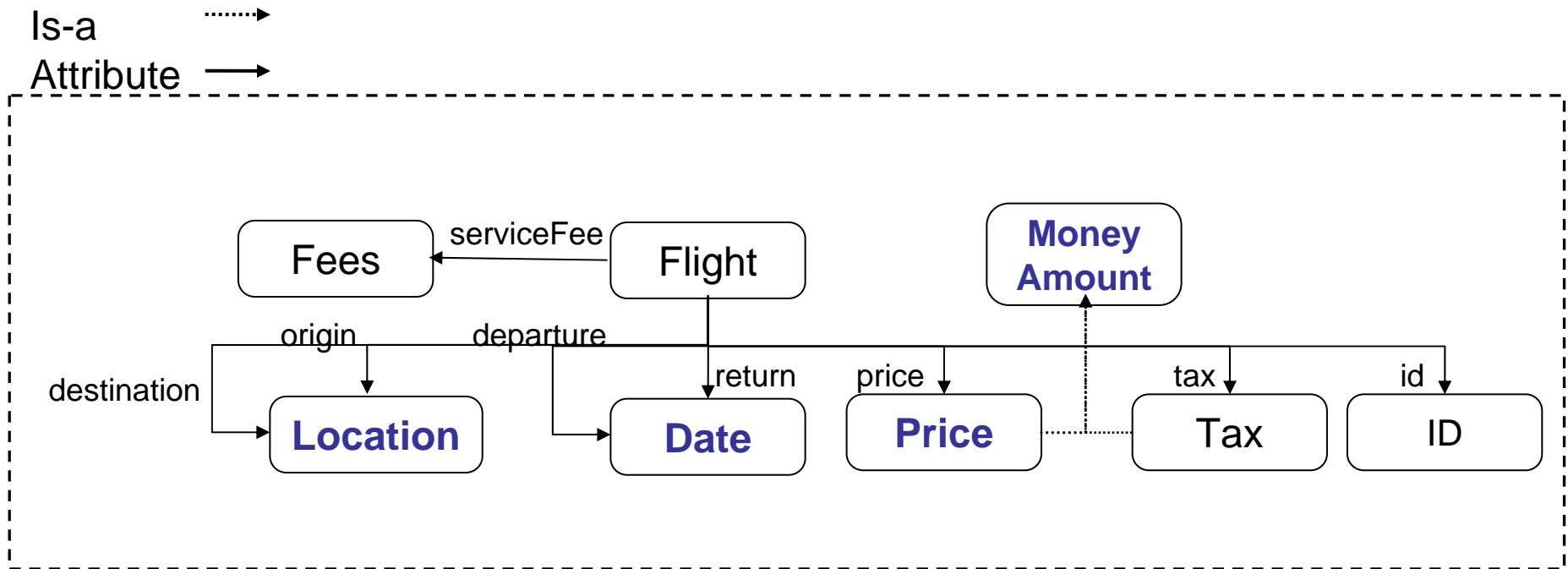
Use of Ontologies for COntext INterchange (COIN)



Ontologies & Interoperability: Assume Single Viewpoint

- For specific domains, ontologies provide a common language for integrating semantically heterogeneous sources
- These ontologies are assumed to correspond to a single integrated view at a given time
- Requires notoriously arduous process of agreeing on the meaning of ontological terms (e.g., what should “price” mean?)
- Introduces inflexibility for ontology development and evolution. Discourages and delays dev., adoption.

Example: Airfare Ontology



This ontology attaches a single meaning to:

Location (i.e. either as city names or Airport codes)

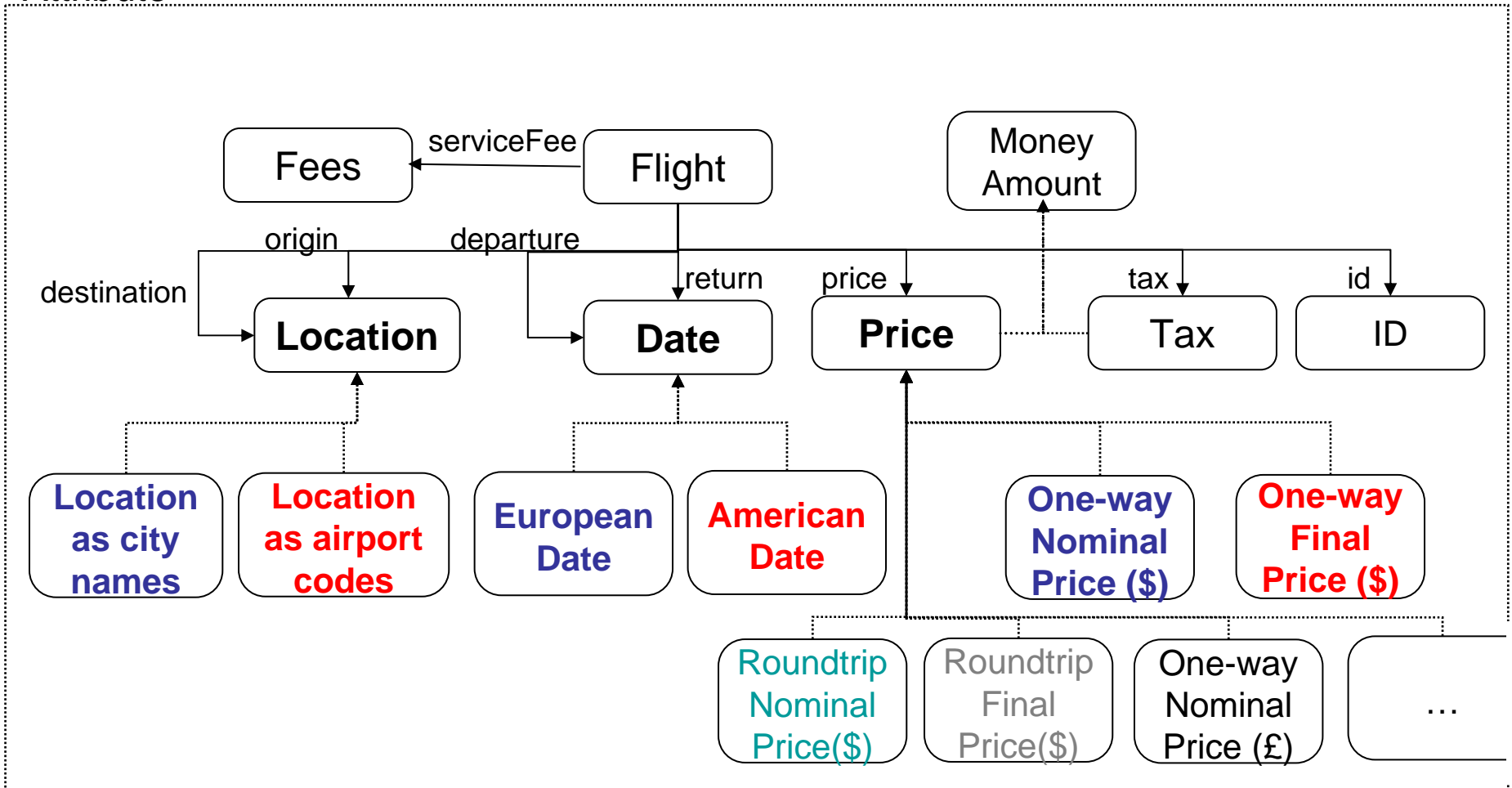
Date (i.e. European or American format)

Price (i.e. as nominal price or final price or ...)

Money amount (i.e. in a specific currency)

...Or we unnecessarily clutter the Ontology

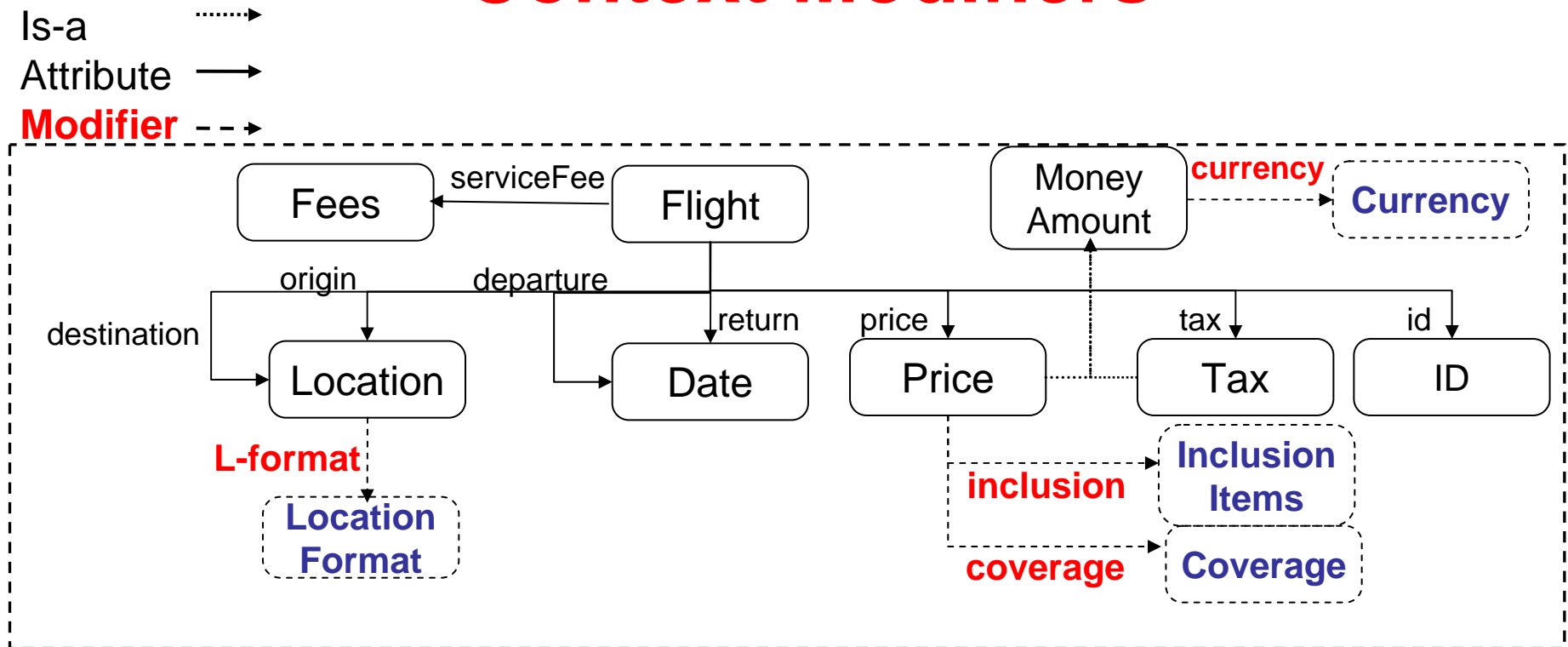
Is-a →
Attribute →



Single Ontology, Multiple Meanings

- Agree to disagree in a standard way
 - Abstracted ontology. Multiple meanings via contextualizing modifiers
- Allows an ontological term to acquire multiple meanings in different contexts
- Increased flexibility
 - Multiple integrated views
 - Reduced need for agreement on meanings
- Accomplished through the introduction of **contexts**
 - A generic context is a collection of modifiers
 - A modifier is a meta-attribute
 - support variability in representation
 - nuances in meaning
 - A specific context is a collection of modifier values

Airfare Ontology: Simplified Via Context Modifiers

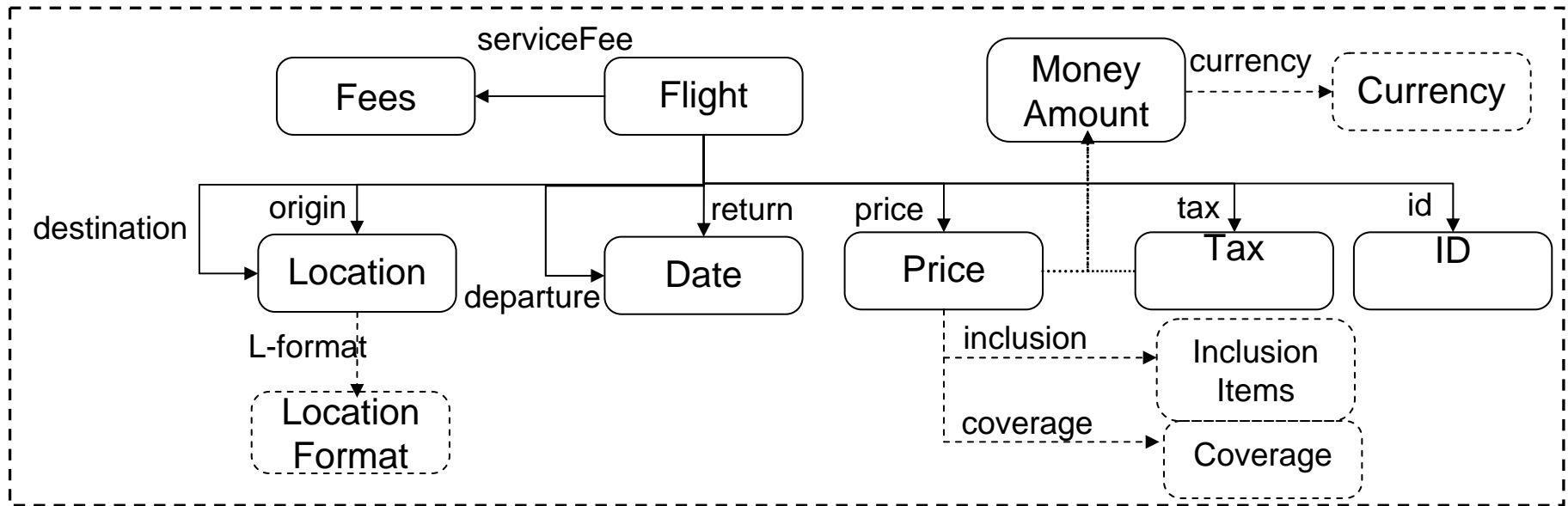


Through the introduction of modifiers

Currency, L-format, inclusion and coverage,

the above ontology allows variations in representation and nuances in meaning.

Multiple Meanings via Contexts



Contexts

Context A1

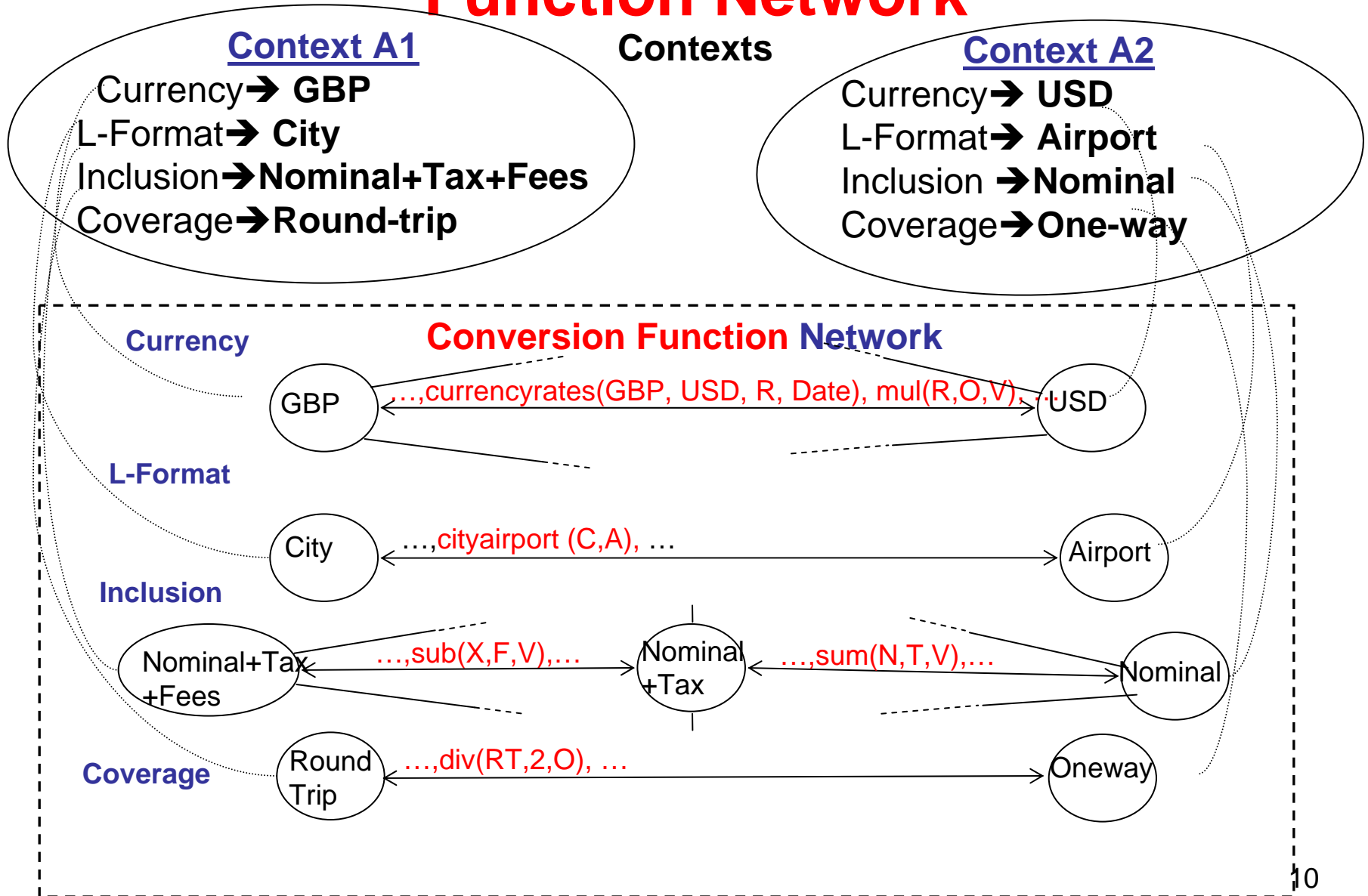
Currency → **GBP**
 L-Format → **City**
 Inclusion → **Nominal+Tax+Fees**
 Coverage → **Round-trip**

Context A2

Currency → **USD**
 L-Format → **Airport**
 Inclusion → **Nominal**
 Coverage → **One-way**

Note: modifiers can have modifiers/contextes (e.g., currency code format)

Context Reconciliation via Conversion Function Network

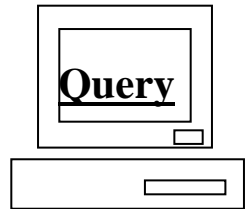


AIRFARE SCENARIO

User A in Context A1

- * Fares are expected to be bottom-line price (round trip, includes taxes and fees)
- * Departure and Destination locations are expressed as city names
- * Currency is GBP
- * Today's date: 05/01/04

**Q1: SELECT Price FROM cheaptickets
WHERE DepartureDate = "06/01/04"
and ArrivalDate= "07/01/04" and
DepartureCity= "Boston"
and ArrivalCity= "Istanbul";**



Cheaptickets in Context A2

- * All fares are for each way of travel and do not include fees and taxes.
- * Currency is USD
- * Departure and Destination locations are expressed as three letter airport codes
- * Lufthansa offers 10% discount if the airfare is bundled with National car rental

* Service fee of \$5 is charged

cheaptickets

<u>ID</u>	<u>Airline</u>	<u>Price</u>	<u>Tax</u>	<u>DepDate</u>	<u>ArrDate</u>	<u>DepCity</u>	<u>ArrCity</u>
1	British Airways	495	75	06/01/04	08/01/04	BOS	IST
2	Lufthansa	510	77	06/01/04	08/01/04	BOS	IST

currencyrates

<u>FromCur</u>	<u>ToCur</u>	<u>eRate</u>	<u>Date</u>
GBP	USD	1.75	05/01/04
EUR	USD	1.25	05/01/04

cityairport

<u>City</u>	<u>Airport</u>
Boston	BOS
Istanbul	IST

AIRFARE RESULTS

MEDIATED QUERY (MQ1):

SELECT Airline, (2* (Price+Tax) + 5) * eRate
FROM cheaptickets, currencyrates, (select Airport from cityairport where city= "Boston") cityairport1,
 (select Airport from cityairport where city= "Istanbul") cityairport2
WHERE DepDate = "06/01/04" and ArrDate="07/01/04" and
 DepCity= cityairport1.Airport and ArrCity= cityairport2.Airport
 and fromCur= "USD" and toCur= "GBP" and Date= "05/10/04";

Q1: SELECT Price FROM cheaptickets
WHERE DepartureDate = "06/01/04"
 and ArrivalDate= "07/01/04" and
 DepartureCity= "Boston"
 and ArrivalCity= "Istanbul";

Results:

<u>Airline</u>	<u>Price</u>
British Airways	654
Lufthansa	674

cheaptickets

<u>ID</u>	<u>Airline</u>	<u>Price</u>	<u>Tax</u>	<u>DepDate</u>	<u>ArrDate</u>	<u>DepCity</u>	<u>ArrCity</u>
1	British Airways	495	75	06/01/04	08/01/04	BOS	IST
2	Lufthansa	510	77	06/01/04	08/01/04	BOS	IST

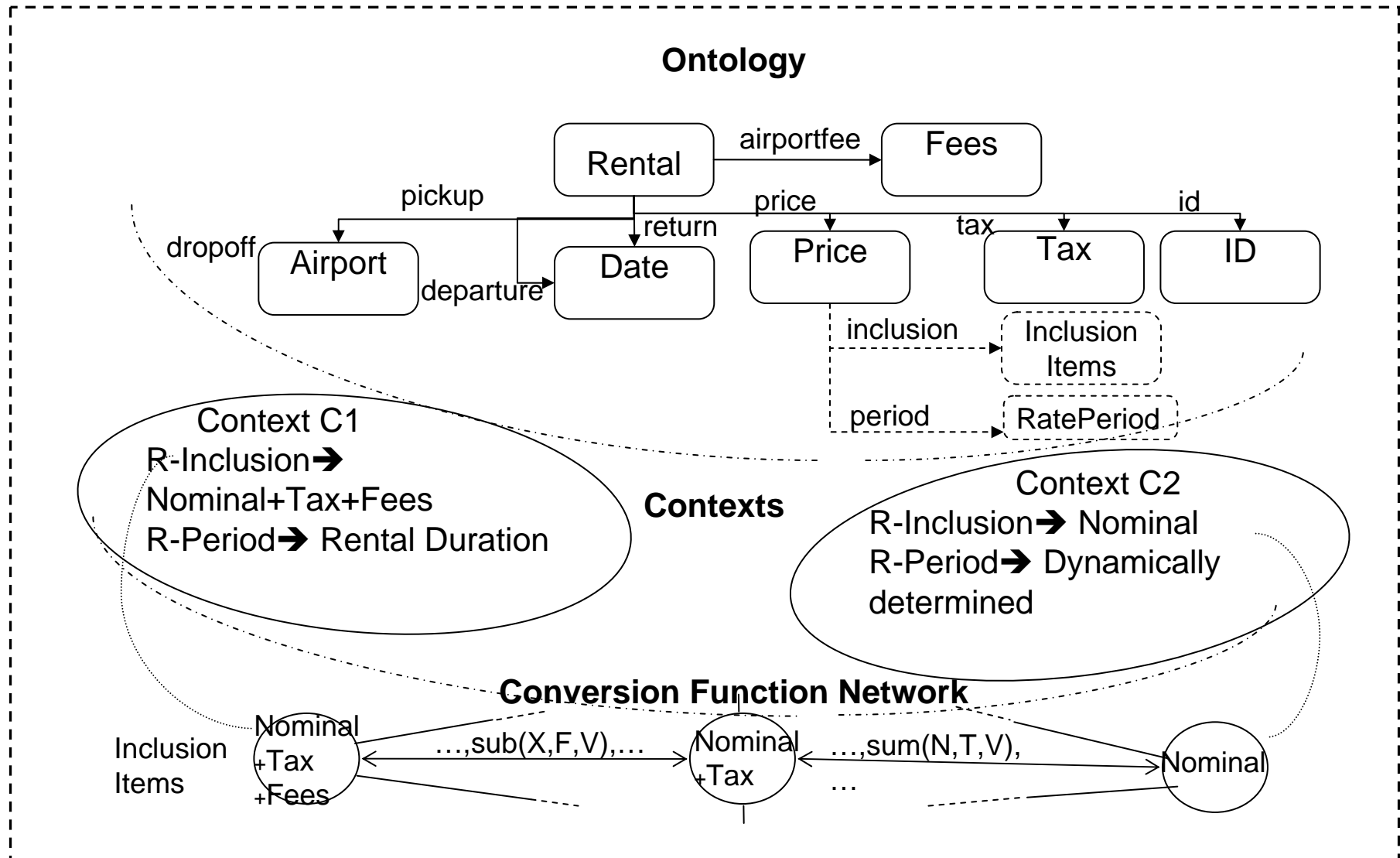
currencyrates

<u>FromCur</u>	<u>ToCur</u>	<u>eRate</u>	<u>Date</u>
GBP	USD	1.75	05/01/04
EUR	USD	1.25	05/01/04

cityairport

<u>City</u>	<u>Airport</u>
Boston	BOS
Istanbul	IST

2nd Ontology: European Car Rental



Note: Shared understanding (assumption) that currency is Euros and European style dates, thus no modifiers included in this ontology.

CAR RENTAL SCENARIO

User C in Context C1

- * Rentals are expected to be bottom-line price (includes taxes, and fees)
- * Rates are for the rental duration

**Q2: SELECT Price FROM cheaprentals
WHERE Class= "Economy" and
PickDate = "02/06/04" and
DropDate= "01/07/04" and
Pickup= "IST" and DropOff= "IST";**

Cheaprentals in Context C2

- * Rentals do not include fees and taxes.
- * Rates are daily
- * National offers 10% discount if the car rental is bundled with a Lufthansa airfare
- * Airport concession recovery fee %10
- * Sales tax is 5%

cheaprentals

<u>ID</u>	<u>Company</u>	<u>Pickup</u>	<u>DropOff</u>	<u>PickDate</u>	<u>DropDate</u>	<u>Price</u>	<u>Class</u>	<u>RatePeriod</u>
1	Hertz	IST	IST	02/06/04	01/07/04	23.99	Economy	Daily
2	National	IST	IST	02/06/04	01/07/04	27.99	Economy	Daily

Note: Shared understanding in C1 and C2 that currency is Euros and European style dates.

CAR RENTAL RESULTS

```
Q2: SELECT Price
FROM cheaprentals
WHERE Class= "Economy" and
PickDate = "02/06/04" and
DropDate= "01/07/04" and
Pickup= "IST" and DropOff= "IST";
```

MEDIATED QUERY (MQ2):

```
SELECT Company, Price * 34.65
```

Note: $34.65 = 30 * 1.1 * 1.05$,
Includes total rental days, concession fee, and sales tax

```
FROM cheaprentals, (select Airport from cityairport where city= "Istanbul") cityairport
WHERE Class= "Economy" and PickDate = "02/06/04" and DropDate= "01/07/04" and
Pickup= cityairport.Airport and DropOff= cityairport.Airport;
```

Results:

<u>Company</u>	<u>Price</u>
Hertz	831
National	998

cheaprentals

<u>ID</u>	<u>Company</u>	<u>Pickup</u>	<u>DropOff</u>	<u>PickDate</u>	<u>DropDate</u>	<u>Price</u>	<u>Class</u>	<u>RatePeriod</u>
1	Hertz	IST	IST	02/06/04	01/07/04	23.99	Economy	Daily
2	National	IST	IST	02/06/04	01/07/04	27.99	Economy	Daily

AIRFARE & CAR RENTAL APPLICATIONS COMBINED

User Merged Context M1

- * Both Rentals and Fares are expected to be bottom-line & bundle price
- * Date is expressed in American style
- * Both Rental and flight locations are expressed as city names
- * Currency is Euros

```
Q3: SELECT Airline, Company, t.Price + r.Price
as total
FROM cheaptickets t, cheaprentals r
WHERE DepDate = "06/01/04"
and ArrDate= "07/01/04"
and DepCity= "Boston"
and ArrCity= "Istanbul";
Pickup="Istanbul" and Dropoff="Istanbul" and
PickDate="06/02/04" and DropDate="07/01/04";
```

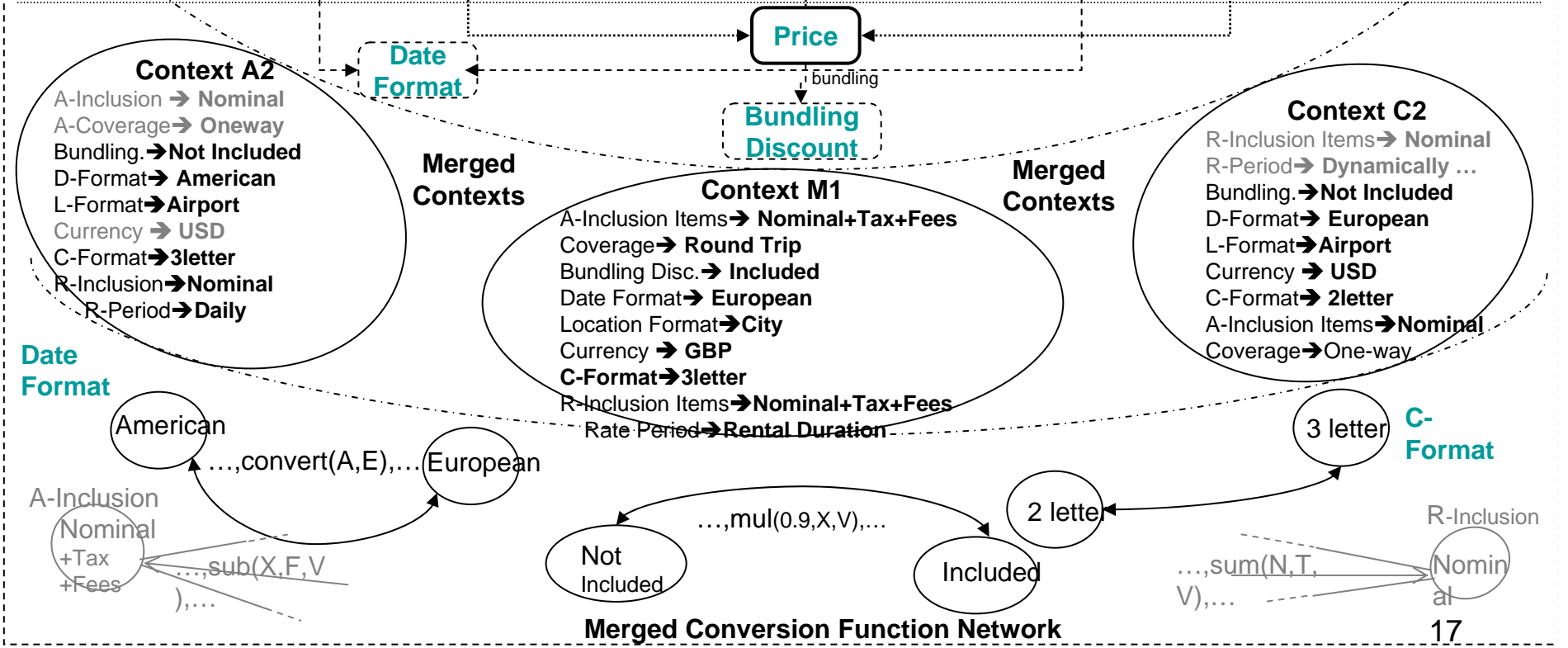
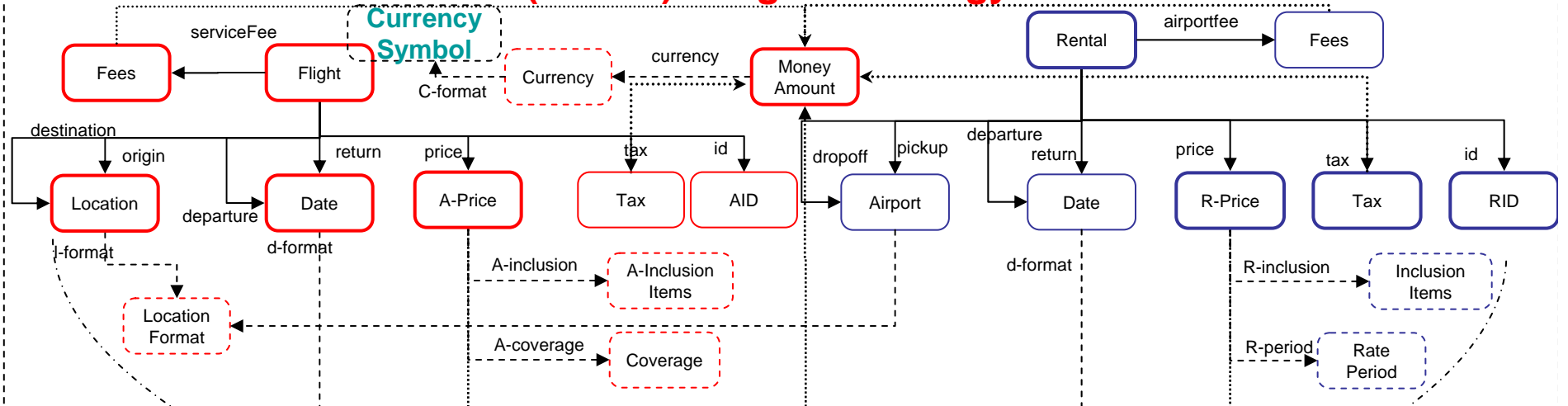
cheaptickets

<u>ID</u>	<u>Airline</u>	<u>Price</u>	<u>Tax</u>	<u>DepDate</u>	<u>ArrDate</u>	<u>DepCity</u>	<u>ArrCity</u>
1	British Airways	495	75	06/01/04	08/01/04	BOS	IST
2	Lufthansa	510	77	06/01/04	08/01/04	BOS	IST

cheaprentals

<u>ID</u>	<u>Company</u>	<u>Pickup</u>	<u>DropOff</u>	<u>PickDate</u>	<u>DropDate</u>	<u>Price</u>	<u>Class</u>	<u>RatePeriod</u>
1	Herts	IST	IST	02/06/04	01/07/04	23.99	Economy	Daily
2	National	IST	IST	02/06/04	01/07/04	27.99	Economy	Daily

(Virtual) Merged Ontology



Merging Overview (abbreviated)

Hybrid of:

- **Ontology Merging**

- Produce new (but virtual) ontology
- Inherits from base ontologies
 - Car rental gains city name <--> airport code capabilities from Air fare ontology

- **Alignment Approaches**

- Use articulation axioms to align ontologies
- New terms, relationships, and modifiers can be added
 - Multiple date formats now exist, so need date format modifier
 - “Bundled” price concept added

Conversion Network also extended

- To handle “bundling”, date format, currency format conversions

AIRFARE & CAR RENTAL RESULTS

Note: Bundling discount

MEDIATED QUERY

```
SELECT "Lufthansa", "National", ((2 * (t.Price + Tax )+5) * eRate + r.Price * 34.65) * 0.9 as total
FROM   cheaptickets t, currencyrates, cheaprentals r,
       (select Airport from cityairport where city= "Boston") cityairport1,
       (select Airport from cityairport where city= "Istanbul") cityairport2
WHERE  DepDate = "06/01/04" and ArrDate="07/01/04" and  DepCity= cityairport1.Airport and
ArrCity= cityairport2.Airport and fromCur= "USD" and toCur= "EUR" and Date= "05/10/04" and
Airline="Lufthansa" and Company="National"and Class= "Economy" and PickDate = "02/06/04" and
DropDate= "01/07/04" and Pickup= cityairport2.Airport and DropOff= cityairport2.Airport
UNION
SELECT Airline, Company, ((2 * (t.Price + Tax )+5) * eRate + r.Price * 34.65) as total
FROM cheaptickets t, currencyrates, cheaprentals r, (select Airport from cityairport where city=
"Boston")
cityairport1, (select Airport from cityairport where city= "Istanbul") cityairport2
WHERE DepDate = "06/01/04" and ArrDate="07/01/04" and  DepCity= cityairport1.Airport and
ArrCity= cityairport2.Airport and fromCur= "USD" and toCur= "EUR" and Date= "05/10/04" and
(Airline<>"Lufthansa" or Company<>"National") and Class= "Economy" and PickDate = "02/06/04"
and DropDate= "01/07/04" and Pickup= cityairport2.Airport and DropOff=cityairport2.Airport
```

Results:

<u>Airline</u>	<u>Company</u>	<u>Total</u>
British Airways	Hertz	1747
British Airways	National	1913
Lufthansa	Hertz	1775
Lufthansa	National	1747

Conclusions

- A single ontology can accommodate multiple views
 - Through use of context modifiers and
 - Conversion function network
- “Virtually” merged application
 - Creates illusion of a single system
 - Can go across sources & across domains
 - Cross-fertilization of contexts and conversion functions
- Ontology interoperability to support multiple integrated views across domains