Monitoring Entities in an Uncertain World: Entity Resolution and Referential Integrity

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Sofus Macskassy, Fetch Technologies
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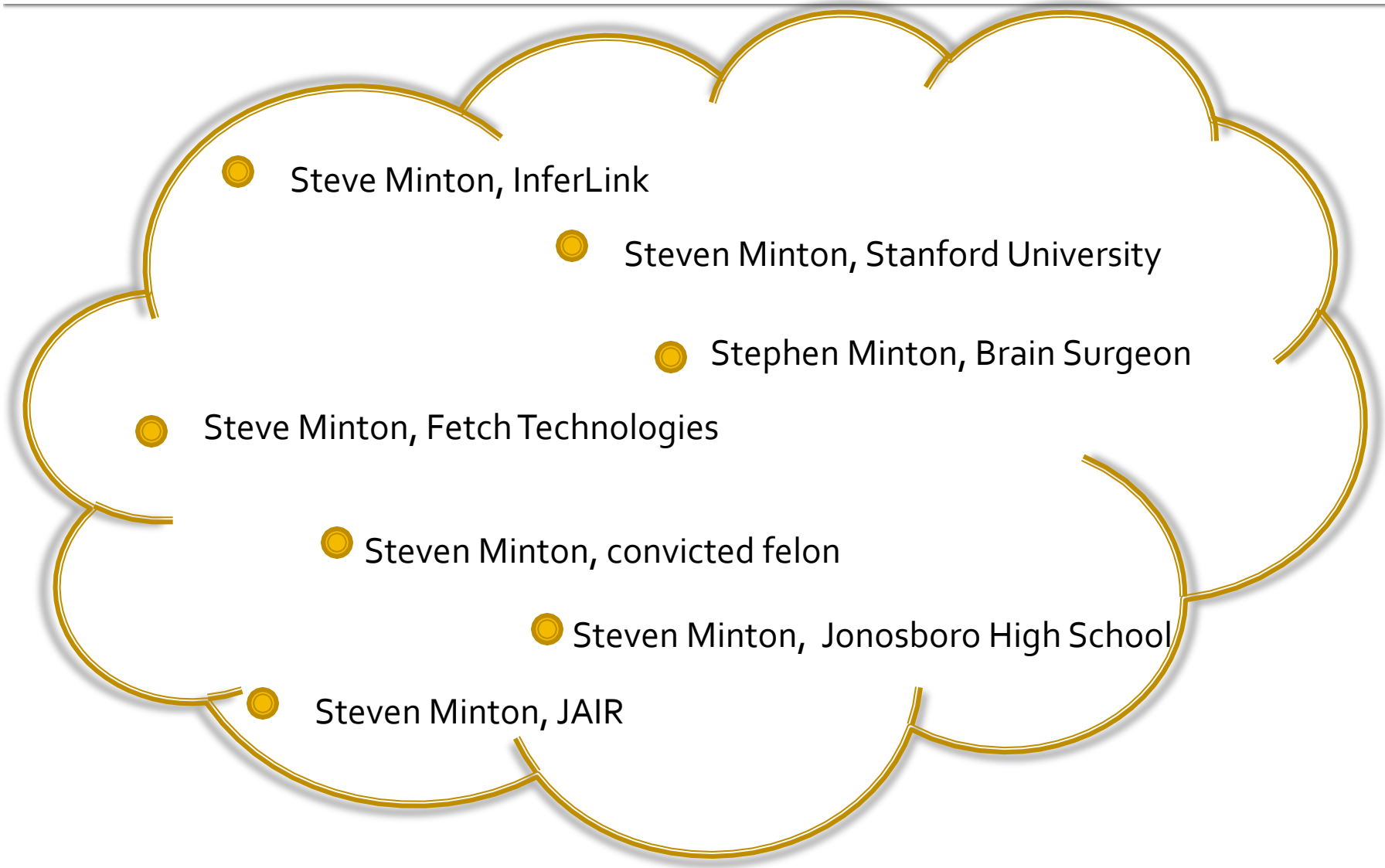
Kane See, InferLink Corporation
Craig Knoblock, USC/Information Sciences Inst.
Greg Barish, Fetch Technologies
Matthew Michelson, Fetch Technologies
Ray Liuzzi, Raymond Technologies

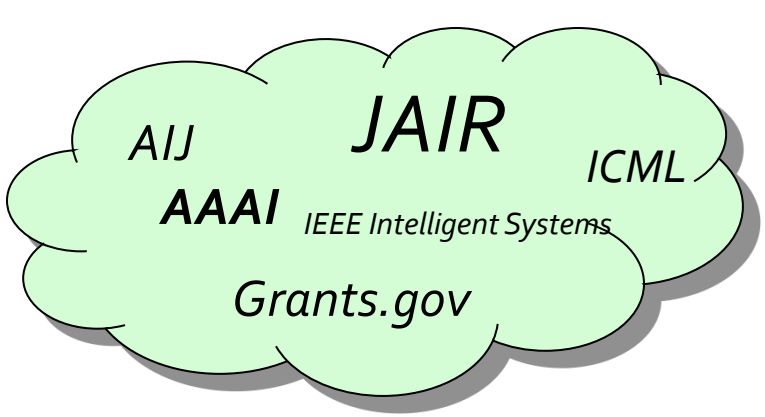
Many "Steve Minton"s

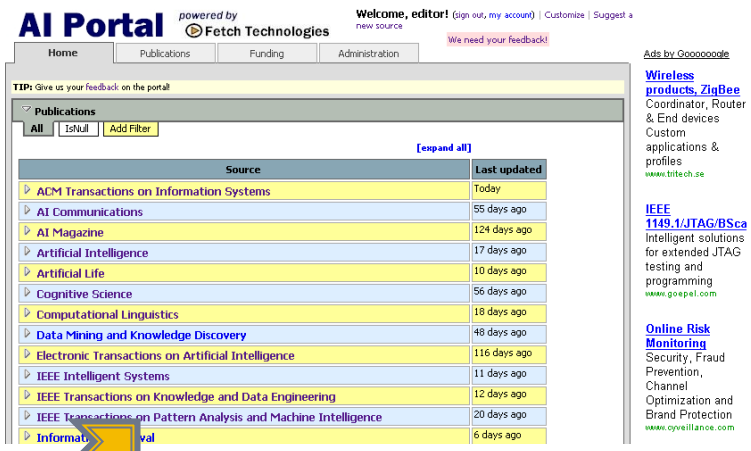


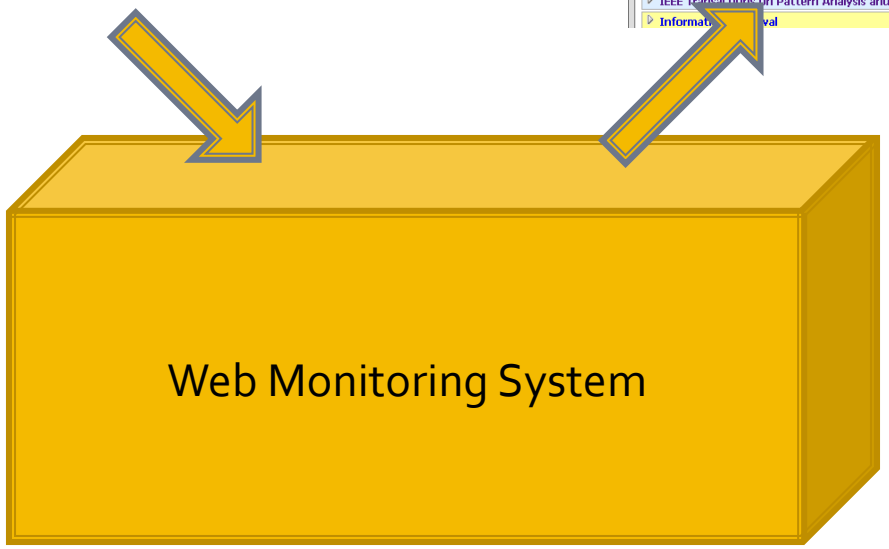
Outline

- Application domain: Arms trafficking
- Entity Intelligence Portal (ENTEL)
- Entity resolution process
- Mistakes: Maintaining referential integrity

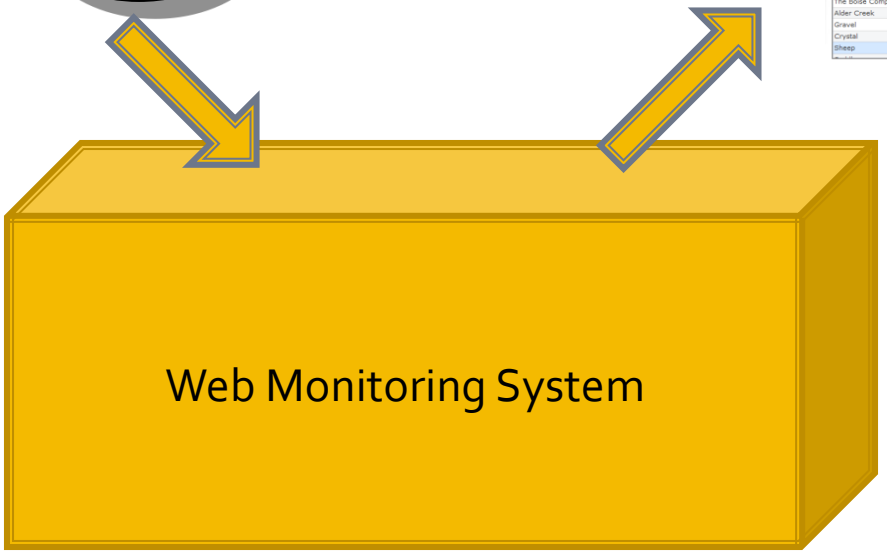
Web Monitoring



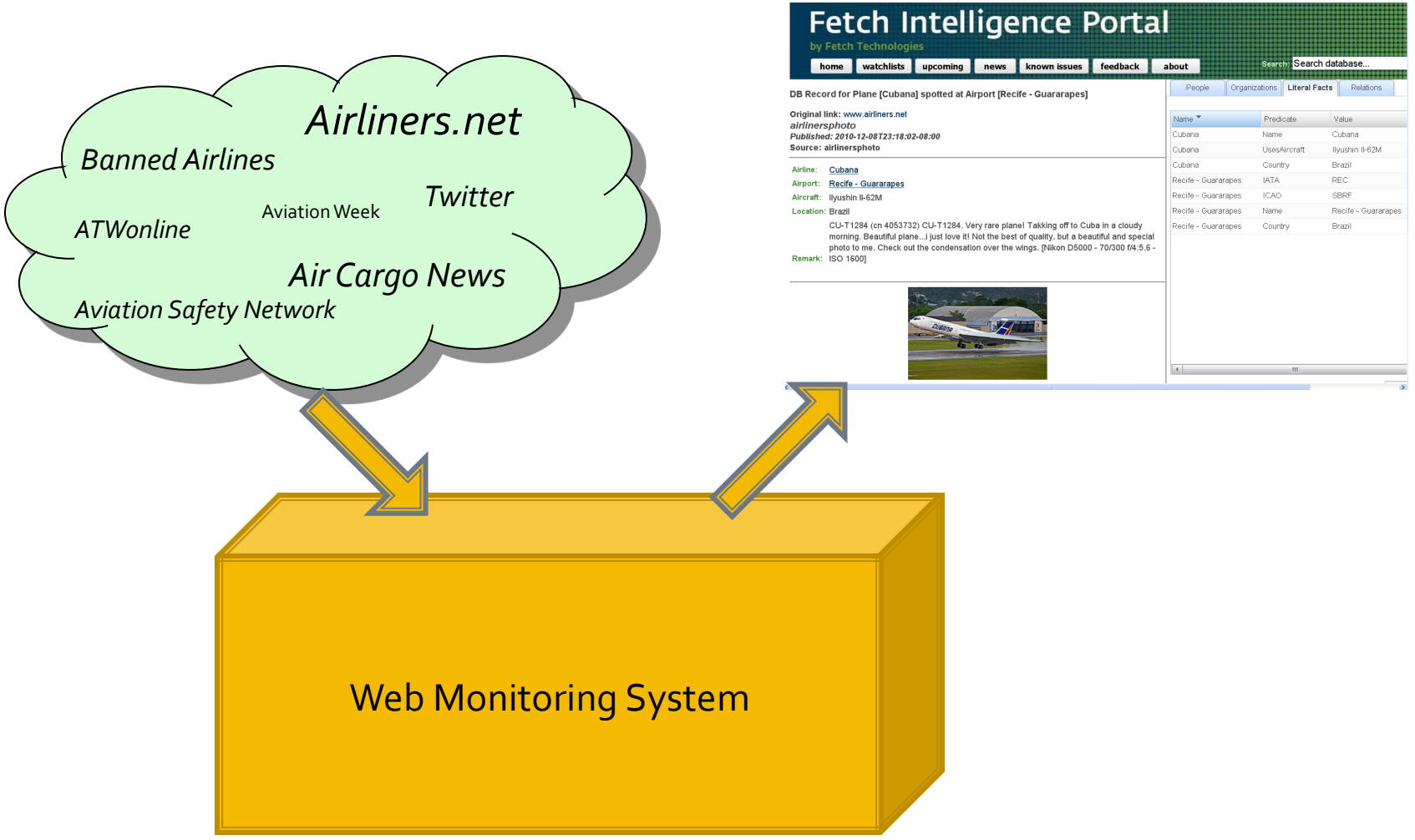




Web Monitoring



Web Monitoring



Victor Bout

Arrested and Extradited in 2010

Charged with conspiracy to support a terrorist organization, money laundering, ….,

Some Companies Linked with Bout

Omega Aircompany

Irbis Air

Ishtar Airlines

Mega Airlines

Aerocom

WING AIR

Norse Air Charter

Air Cess

Galaxy Air

Air Foyle

Click Airways

Centrafricain Airlines

Air Bas

Air Pass

Anikay (Anikai) Airlines

Pietersberg Aviation Services Systems

Santa Cruz Imperial

Great Lake Business Company

Balkh Airlines

Phoenix Aviation

Air Zory

JetLine International

Dolphin Air

Flying Dolphin

Sitrat Air

MaxAvia

San Air General Trading

Air Mero

African Express

Air Leone

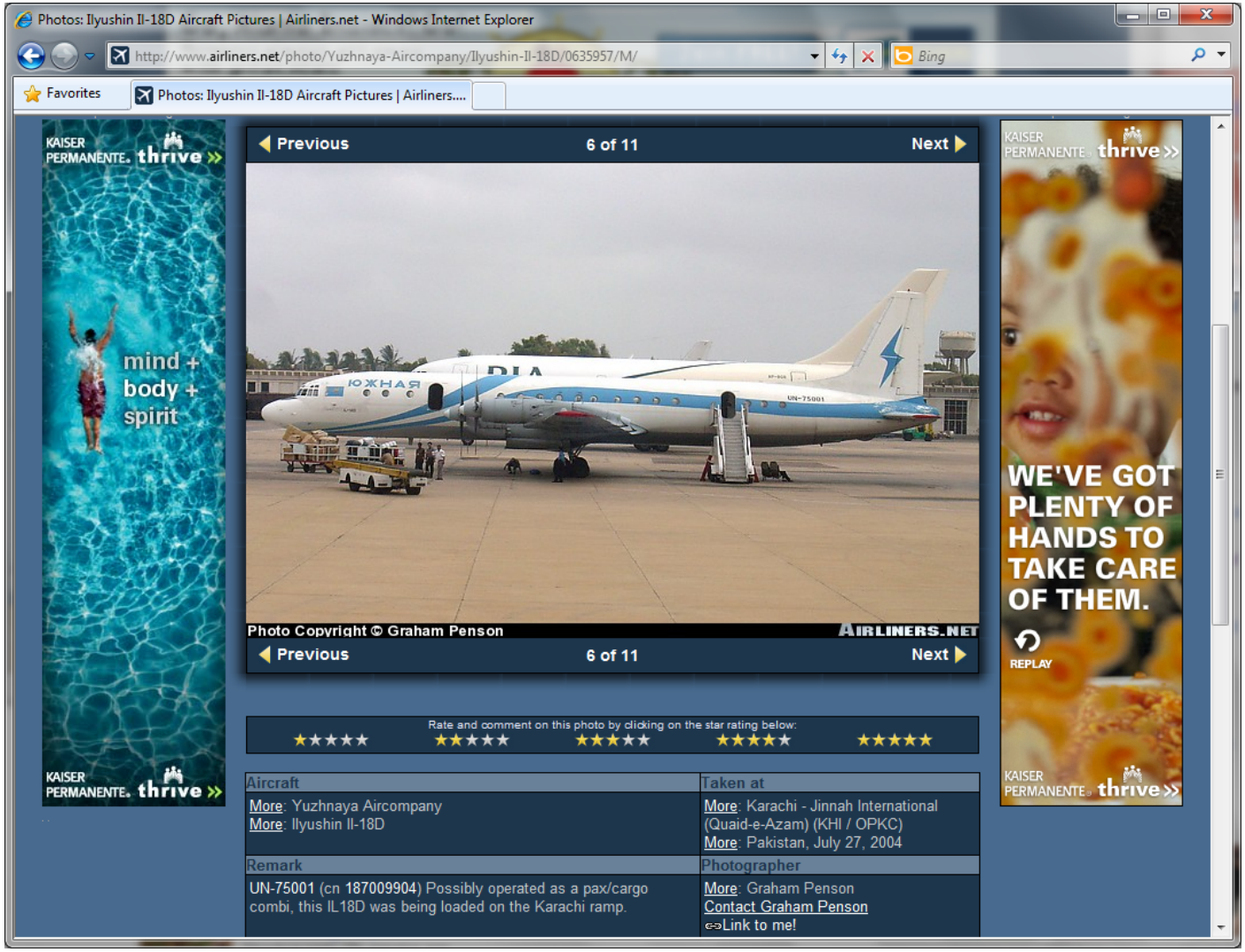
Inter Transavia

One Thread: Air Cess to Air Bas

Registration	Aircraft Type	Construction Nbr	Previous Reg.	Sighting	Markings
UN-75002	Ilyushin 18E	185008603	3C-KKR	SHJ 11May03 SHJ 04Nov03	no markings a/w, n/t
UN-75003	Ilyushin 18V	184006903	3C-KKJ	SHJ 12Oct03	blue tail, no m/s
UN-75004	Ilyushin 18D	186009202	3C-KKK	SHJ 14Sep02 SHJ 04Nov03 SHJ 28Dec03	green cheatline and blue tail No t/t, blue tail all white
UN-75005	Ilyushin 18D	187010204	3C-KKL	SHJ 04Nov03	
UN-11007	Antonov 12B	9346509	3C-OOZ	SHJ Oct02 SHJ 11May03 DXB 12Oct03	No m/s all white c/s no titles

[From Ruudleeuw.com]

An Online Data Source



Another Source

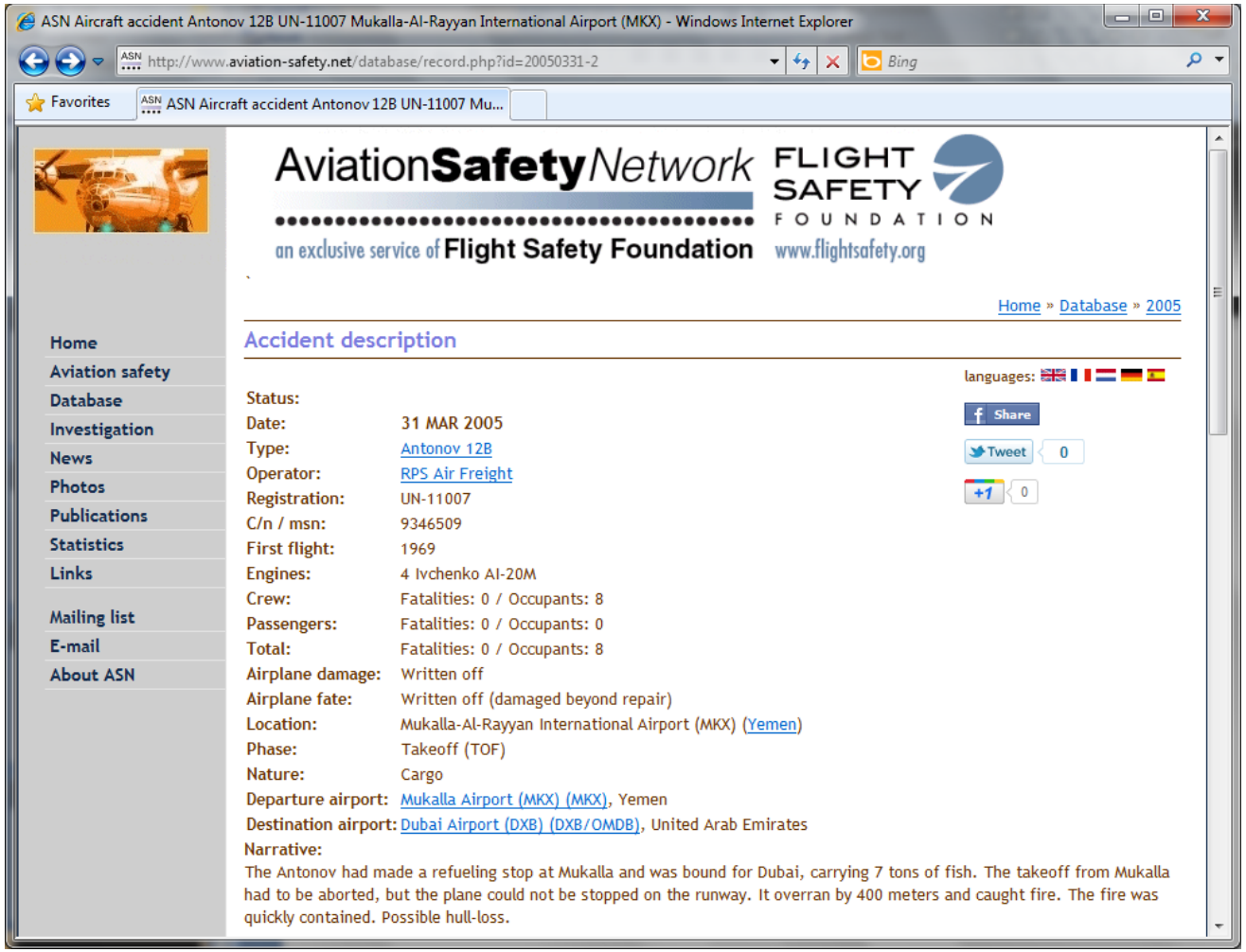
Antonovs AN-8 and AN-12 at Sharjah - Windows Internet Explorer

http://www.ruudleeuw.com/an8_and_12.htm

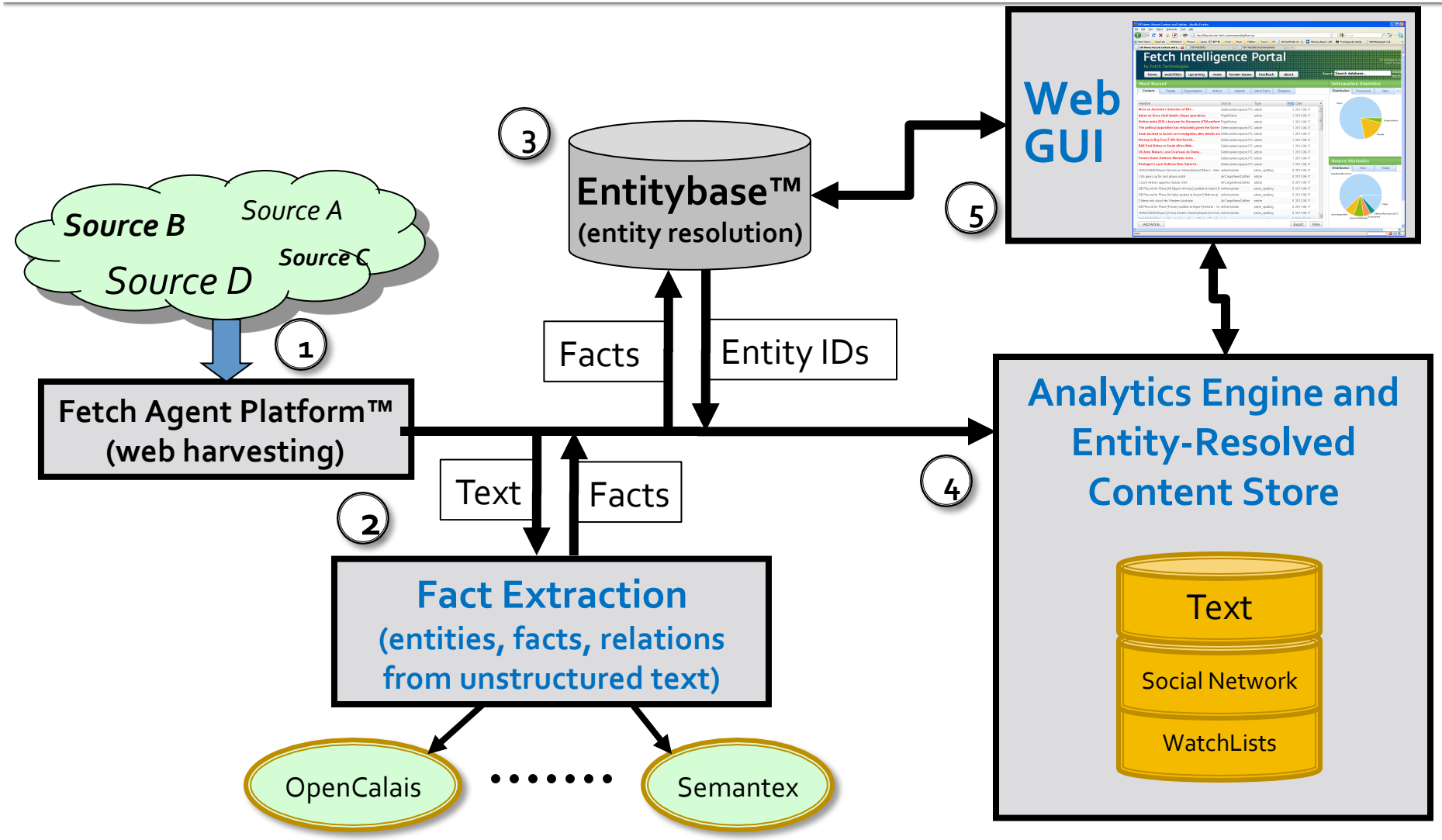
Favorites | Antonovs AN-8 and AN-12 at Sharjah

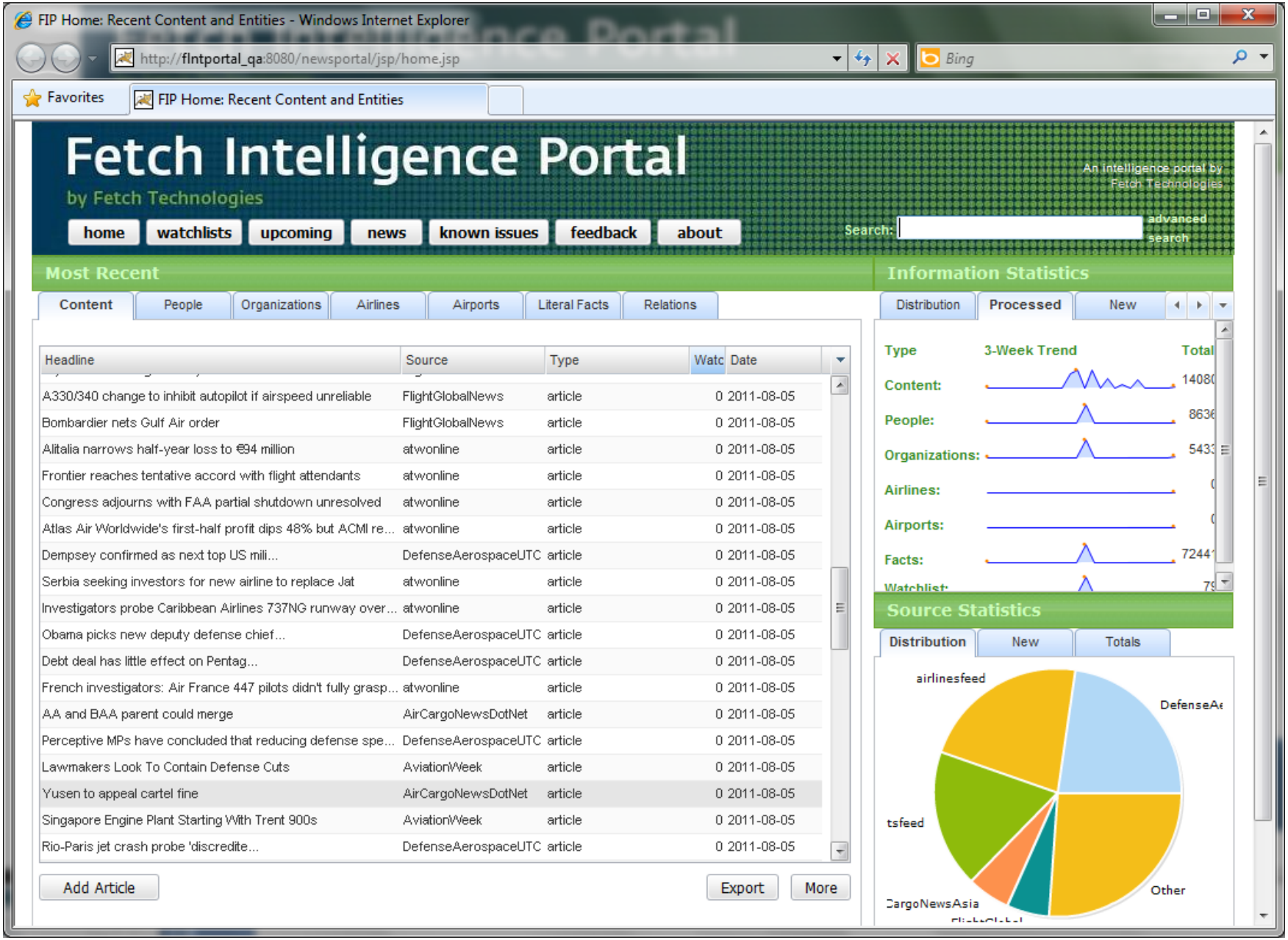
This AN-12B 3C-OOZ (c/n 9346509) still wears the colourful scheme of Ural Airlines, but it seems likely that it is now operated by someone else. I took this photo april 26th, 2000 at Sharjah and as it was still around in 2001, one can assume that Sharjah has become its homebase. They probably have a reason for not advertising the name of the company on the aircraft, pity.....

One More Source



ENTEL Architecture




FIP Home: Recent Content and Entities - Windows Internet Explorer
http://flntportal_qa:8080/newsportal/jsp/home.jsp
Bing
Favorites
FIP Home: Recent Content and Entities
Fetch Intelligence Portal
by Fetch Technologies
An intelligence portal by Fetch Technologies
home
watchlists
upcoming
news
known issues
feedback
about
Search:
advanced search
Most Recent
Content
People
Organizations
Airlines
Airports
Literal Facts
Relations
Headline
Source
Type
Watc
Date
A330/340 change to inhibit autopilot if airspeed unreliable FlightGlobalNews article 0 2011-08-05
Bombardier nets Gulf Air order FlightGlobalNews article 0 2011-08-05
Alitalia narrows half-year loss to €94 million atwonline article 0 2011-08-05
Frontier reaches tentative accord with flight attendants atwonline article 0 2011-08-05
Congress adjourns with FAA partial shutdown unresolved atwonline article 0 2011-08-05
Atlas Air Worldwide's first-half profit dips 48% but ACMI re... atwonline article 0 2011-08-05
Dempsey confirmed as next top US mili... DefenseAerospaceUTC article 0 2011-08-05
Serbia seeking investors for new airline to replace Jat atwonline article 0 2011-08-05
Investigators probe Caribbean Airlines 737NG runway over... atwonline article 0 2011-08-05
Obama picks new deputy defense chief... DefenseAerospaceUTC article 0 2011-08-05
Debt deal has little effect on Pentag... DefenseAerospaceUTC article 0 2011-08-05
French investigators: Air France 447 pilots didn't fully grasp... atwonline article 0 2011-08-05
AA and BAA parent could merge AirCargoNewsDotNet article 0 2011-08-05
Perceptive MPs have concluded that reducing defense spe... DefenseAerospaceUTC article 0 2011-08-05
Lawmakers Look To Contain Defense Cuts AviationWeek article 0 2011-08-05
Yusen to appeal cartel fine AirCargoNewsDotNet article 0 2011-08-05
Singapore Engine Plant Starting With Trent 900s AviationWeek article 0 2011-08-05
Rio-Paris jet crash probe 'discredite... DefenseAerospaceUTC article 0 2011-08-05
Add Article
Export
More
Information Statistics
Distribution
Processed
New
Type
3-Week Trend
Total
Content:
People:
Organizations:
Airlines:
Airports:
Facts:
Watchlist:
Source Statistics
Distribution
New
Totals
airlinesfeed
DefenseAe
tsfeed
Other
CargoNewsAsia

Fetch Intelligence Portal

by Fetch Technologies

home | watchlists | upcoming | news | known issues | feedback | about

Search: S

Watchlist detail for aircarriersbanned

Matches | Members

Entity Name	Content Description	Content Type	Content Source	Date Publish
Volga-Dnepr Airlines	Will Cargo Profiling Take Hold?	article	AirCargoNewsCom	2011-07-27
Volga-Dnepr Airlines	Big Lift To Subcontinent	article	AirCargoNewsCom	2011-07-27
Wings Air	Lion Air, Virgin Blue Add 33 ATR-72 ...	article	DefenseAerospac...	2011-07-27
SonAir	Heli-Expo: Sikorsky Sells 12 Helicop...	article	DefenseAerospac...	2011-07-27
SonAir	Cargo Handlers Get No Respect	article	AirCargoNewsDot...	2011-07-27
SonAir	Prosperous Bosphorous IATA Cargo Week	article	AirCargoNewsDot...	2011-07-27
Volga-Dnepr Airlines	Russian investigators have determined that the Tupolev...	article	FlightGlobal	2011-07-27
Philippine Airlines	Philippine carriers and Iran Air feature on latest EU blac...	article	FlightGlobal	2011-07-27
Air Koryo	Philippine carriers and Iran Air feature on latest EU blac...	article	FlightGlobal	2011-07-27
Citilink	Air Canada, Garuda, Thai and Air Austral could subleas...	article	FlightGlobal	2011-07-27
Volga-Dnepr Airlines	Hearts & Flowers In SWISS SFO	article	AirCargoNewsDot...	2011-07-27
Kartika Airlines	Farnborough International Airshow News	article	atwonline	2011-07-27
Kartika Airlines	Kartika Airlines Orders 30 Sukhoi Su...	article	DefenseAerospac...	2011-07-27
Citilink	Airbus Wins 58 New Orders, Options a...	article	bac...	2011-07-27
Philippine Airlines	AirAsia to launch Philippines-based affiliate	article		2011-07-27
Mandala Airlines	Indonesia's Mandala Airlines suspends operations, see...	article	atwonline	2011-07-27

Indonesia's Mandala Airlines suspends operations, seeks new investors

Fetch Intelligence Portal

by Fetch Technologies

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Search: Search database...

DB Record for Plane [Cubana] spotted at Airport [Recife - Guararapes]

Original link: www.airliners.net
airlinersphoto
Published: 2010-12-08T23:18:02-08:00
Source: airlinersphoto

Airline: Cubana
Airport: Recife - Guararapes
Aircraft: Ilyushin Il-62M
Location: Brazil
Remark: CU-T1284 (cn 4053732) CU-T1284. Very rare plane! Takking off to Cuba in a cloudy morning. Beautiful plane...i just love it! Not the best of quality, but a beautiful and special photo to me. Check out the condensation over the wings. [Nikon D5000 - 70/300 f/4:5.6 - ISO 1600]

People | Organizations | **Literal Facts** | Relations

Name	Predicate	Value
Cubana	Name	Cubana
Cubana	UsesAircraft	Ilyushin Il-62M
Cubana	Country	Brazil
Recife - Guararapes	IATA	REC
Recife - Guararapes	ICAO	SBRF
Recife - Guararapes	Name	Recife - Guararapes
Recife - Guararapes	Country	Brazil

PT Merpati Nusantara Airlines(AIRLINE)

First seen: 2011-07-08T12:35:33-07:00
Last seen: 2009-07-06T07:00:00-07:00
Times seen: 5

Split Entity

Content | Literal Facts | Relations | Add Facts | Watchlists | Aliases | Airports | Routes

Headline	Source	Type	Watchlist	Date
DB record for Merpati Nusantara Airlines	aircarriersbanned	structured_input	0	2011-07-08
DB record for Merpati Nusantara Airlines	airlinesfeed	structured_input	0	2011-07-08
DB Record for Plane [Merpati Nusantara Airlines] spo...	airlinersphoto	plane_spotting	1	2011-07-08
Merpati abandons purchase deal with Xi'an aircraft	CargoNewsAsia	article	2	2009-07-06

PT Merpati Nusantara Airlines(AIRLINE)

First seen: 2011-07-08T12:35:33-07:00
Last seen: 2009-07-06T07:00:00-07:00
Times seen: 5

Split Entity

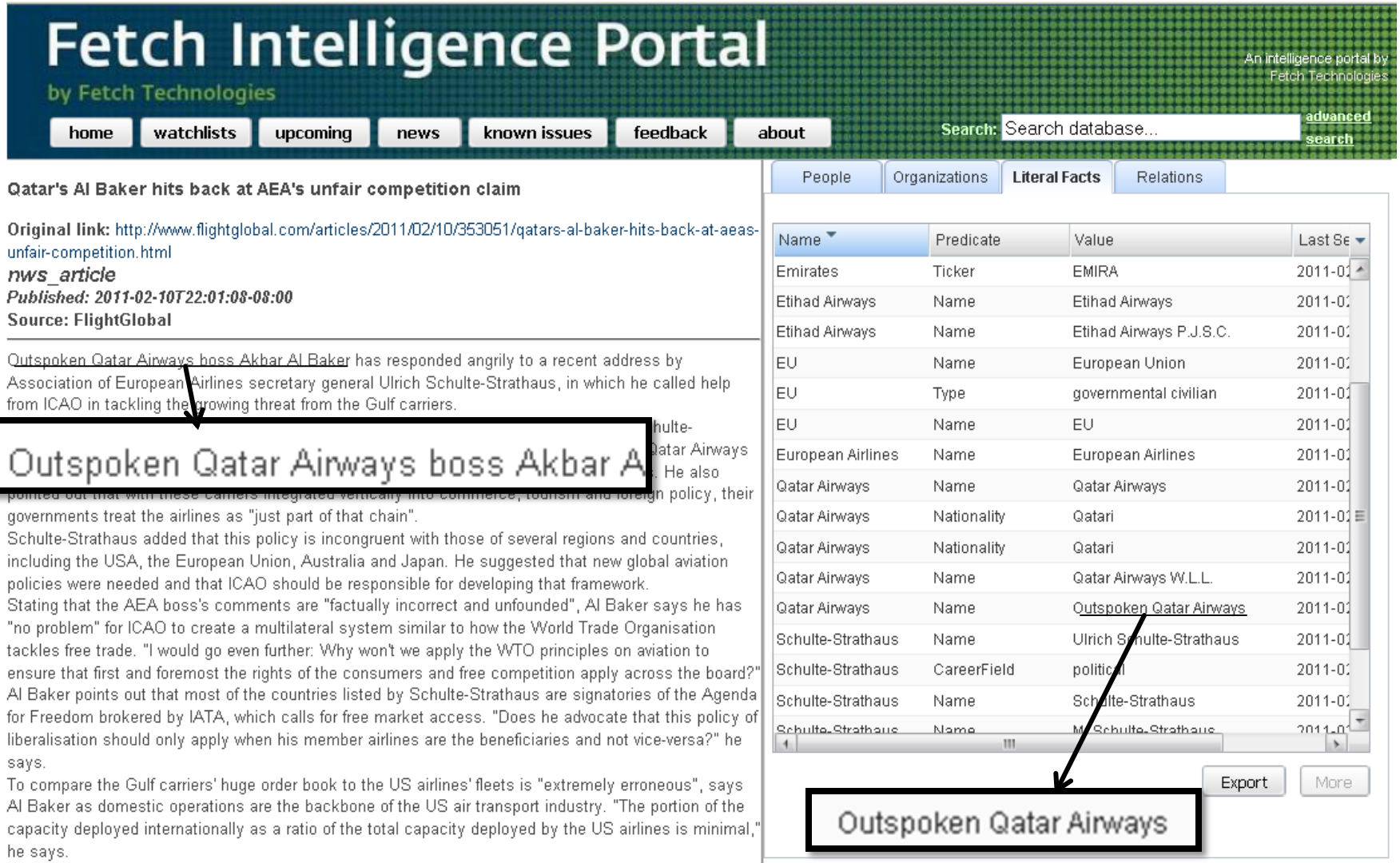
Content | **Literal Facts** | Relations | Add Facts | Watchlists | Aliases | Airports | Routes

Name	Predicate	Value	Last Seen	Frequency
PT Merpati Nusantara Airlines	Name	Merpati Nusantara Airlines	2011-07-08	2
PT Merpati Nusantara Airlines	UsesAircraft	Xian MA-60	2011-07-08	1
PT Merpati Nusantara Airlines	Country	China	2011-07-08	1
PT Merpati Nusantara Airlines	Callsign	MERPATI	2011-07-08	2
PT Merpati Nusantara Airlines	IATA	MZ	2011-07-08	2
PT Merpati Nusantara Airlines	ICAO	MNA	2011-07-08	2
PT Merpati Nusantara Airlines	Country	Indonesia	2011-07-08	2
PT Merpati Nusantara Airlines	Carrier	Merpati Nusantara Airlines	2011-07-08	1
PT Merpati Nusantara Airlines	Name	PT Merpati Nusantara Airlines	2009-07-06	2
PT Merpati Nusantara Airlines	Nationality	Indonesian	2009-07-06	1
PT Merpati Nusantara Airlines	Name	Indonesian state-owned airline...	2009-07-06	1
PT Merpati Nusantara Airlines	Name	Merpati	2009-07-06	2

The Entity Resolution Problem

- Entity resolution: Link incoming records describing the same entity from multiple sources

- Many "common sense" issues, for instance:
  - Multiple formats for names, addresses, etc.
    - R.L. Landes vs. Robert Landes
  - Noisy, incorrect values
    - Landes vs. Landis
  - Multi-valued attributes
    - Landes can be both President and CEO
  - Aliases and Deception



Qatar's Al Baker hits back at AEA's unfair competition claim

Original link: http://www.flightglobal.com/articles/2011/02/10/353051/qatars-al-baker-hits-back-at-aeas-unfair-competition.html

nws_article

Published: 2011-02-10T22:01:08-08:00

Source: FlightGlobal

Outspoken Qatar Airways boss Akbar Al Baker has responded angrily to a recent address by Association of European Airlines secretary general Ulrich Schulte-Strathaus, in which he called help from ICAO in tackling the growing threat from the Gulf carriers.

Outspoken Qatar Airways boss Akbar A

hulte-
atar Airways
. He also
policy, their governments treat the airlines as "just part of that chain".

Schulte-Strathaus added that this policy is incongruent with those of several regions and countries, including the USA, the European Union, Australia and Japan. He suggested that new global aviation policies were needed and that ICAO should be responsible for developing that framework.

Stating that the AEA boss's comments are "factually incorrect and unfounded", Al Baker says he has "no problem" for ICAO to create a multilateral system similar to how the World Trade Organisation tackles free trade. "I would go even further: Why won't we apply the WTO principles on aviation to ensure that first and foremost the rights of the consumers and free competition apply across the board?"

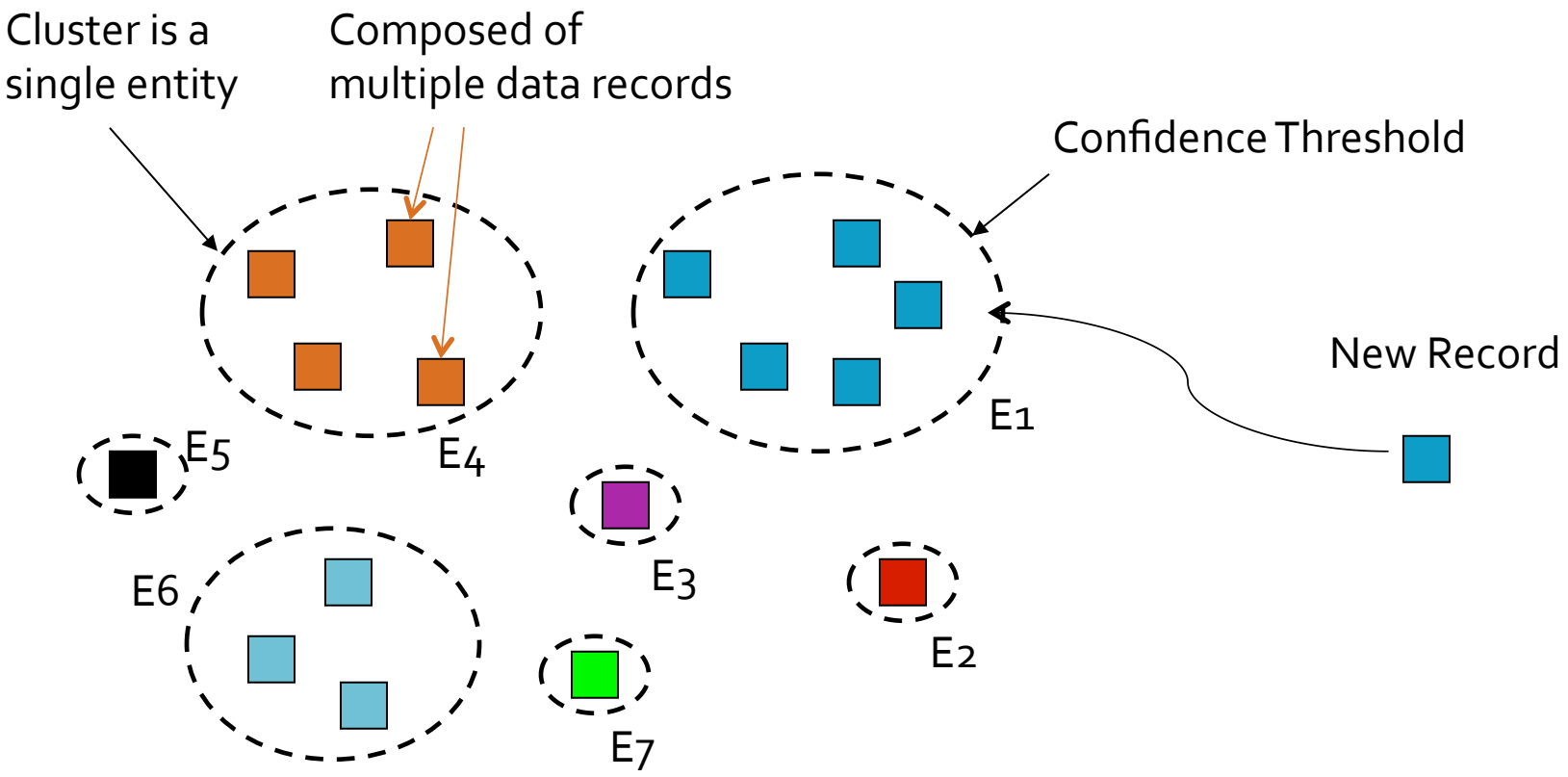
Al Baker points out that most of the countries listed by Schulte-Strathaus are signatories of the Agenda for Freedom brokered by IATA, which calls for free market access. "Does he advocate that this policy of liberalisation should only apply when his member airlines are the beneficiaries and not vice-versa?" he says.

To compare the Gulf carriers' huge order book to the US airlines' fleets is "extremely erroneous", says Al Baker as domestic operations are the backbone of the US air transport industry. "The portion of the capacity deployed internationally as a ratio of the total capacity deployed by the US airlines is minimal," he says.

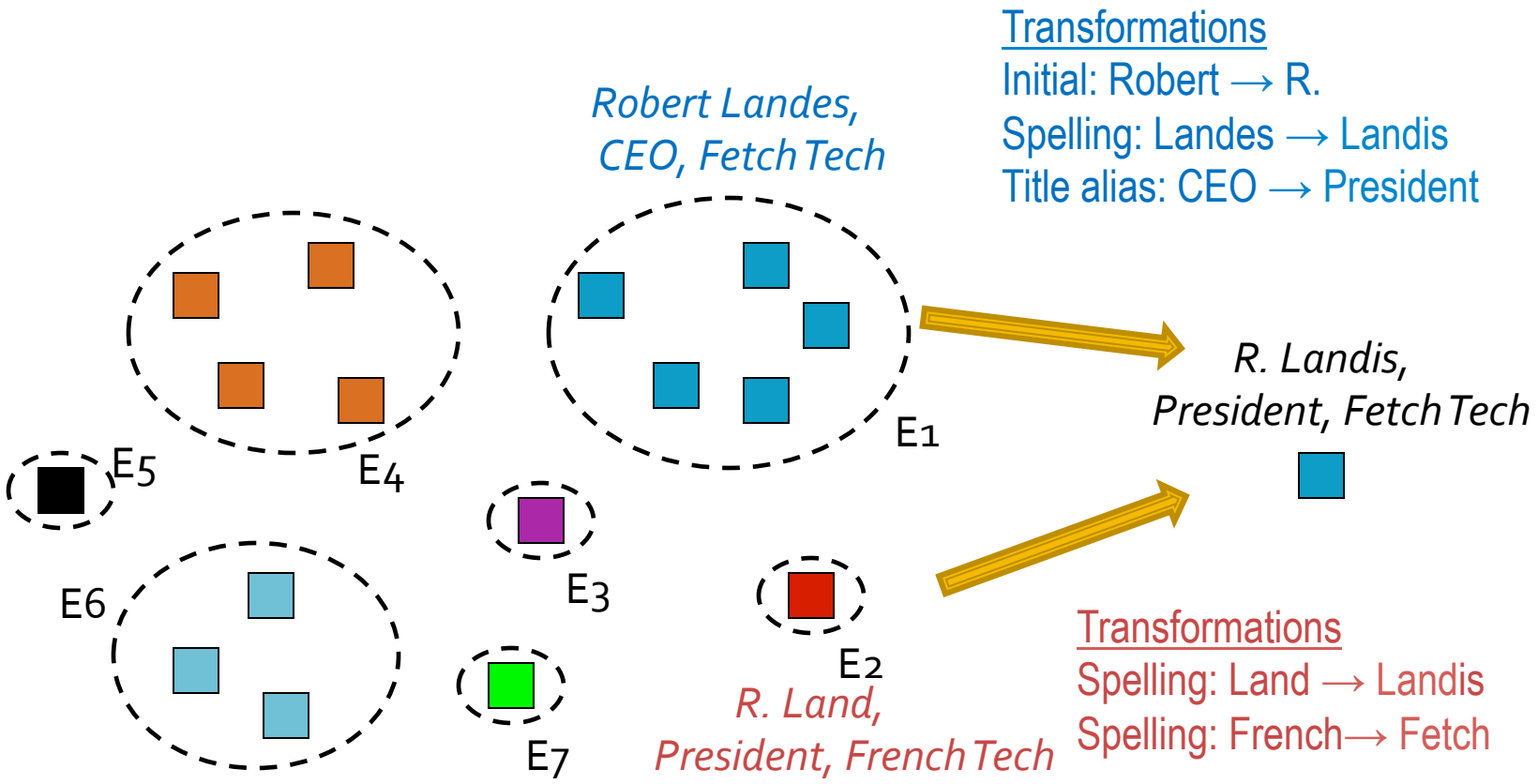
Al Baker also challenges the AEA's view about the Gulf airlines being part of a vertically integrated economic chain: "Can [Schulte-Strathaus] tell me of any country which does not consider its air transport industry, be that an individual airline or a multitude of them, as part of national interests?"

The Qatar Airways chief points to the financial assistance US airlines received from their government after 9/11 "in order to ensure the continuity of the US air transport industry" as well as "the billions of Euros that are allowed under the EU laws to pump into airlines for restructuring purposes".

Clustering in EntityBase



Estimating Probabilities



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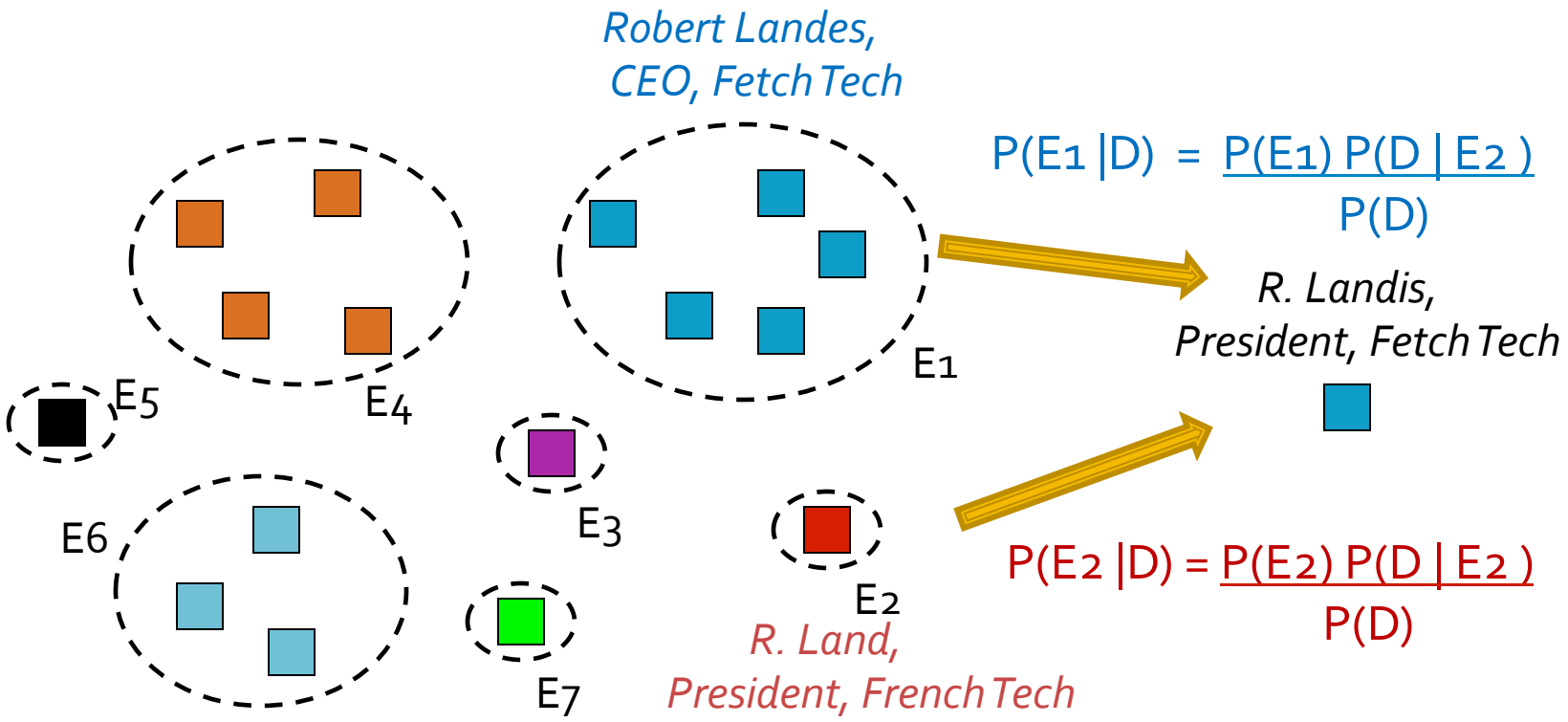

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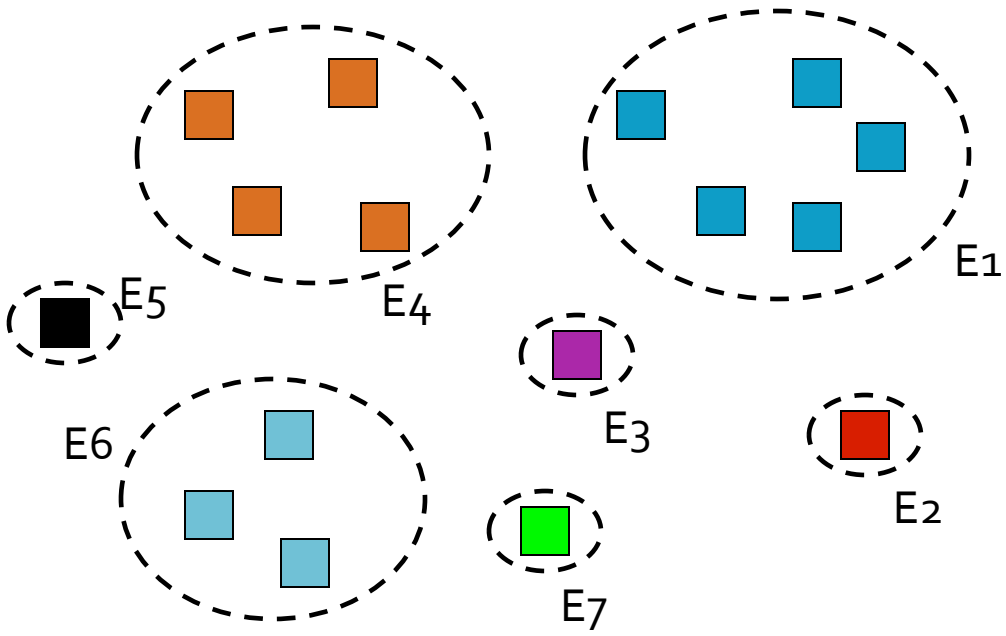
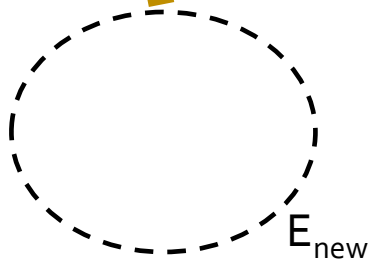
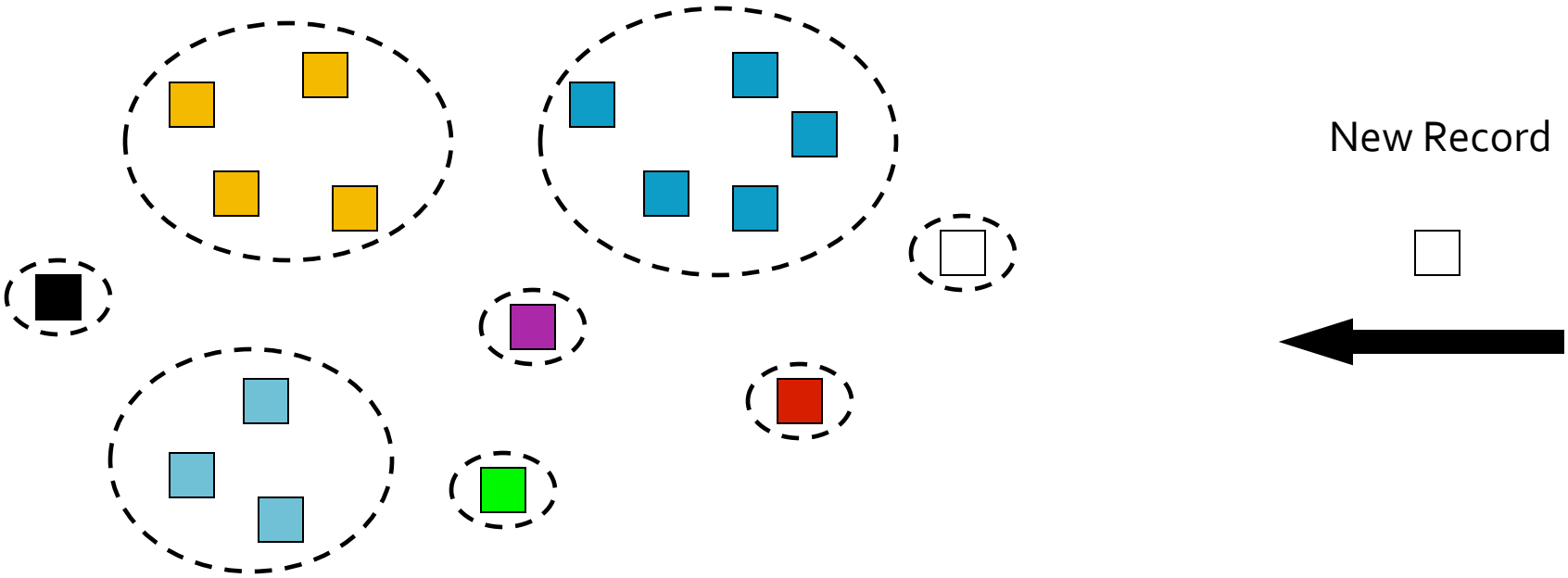


R. Landis,
President, Fetch Tech

$$\frac{P(E_{new})\,P(D \mid E_{new})}{P(D)} \quad ?$$



Clustering



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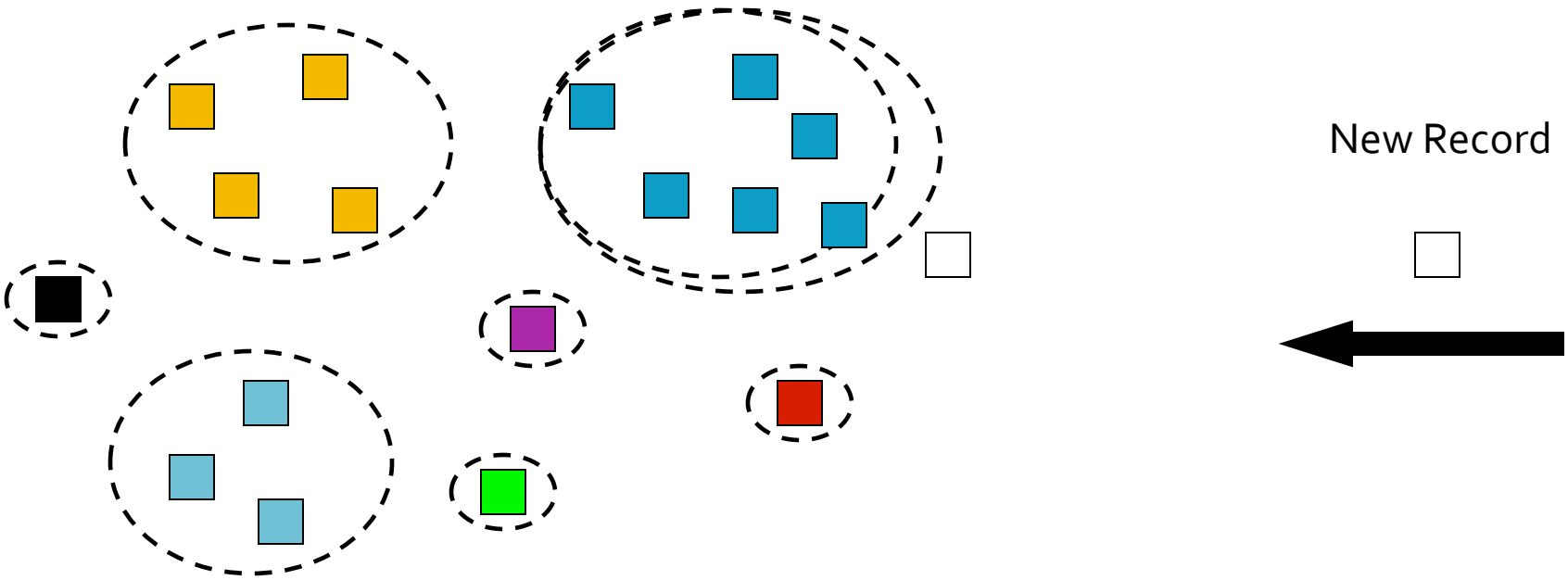

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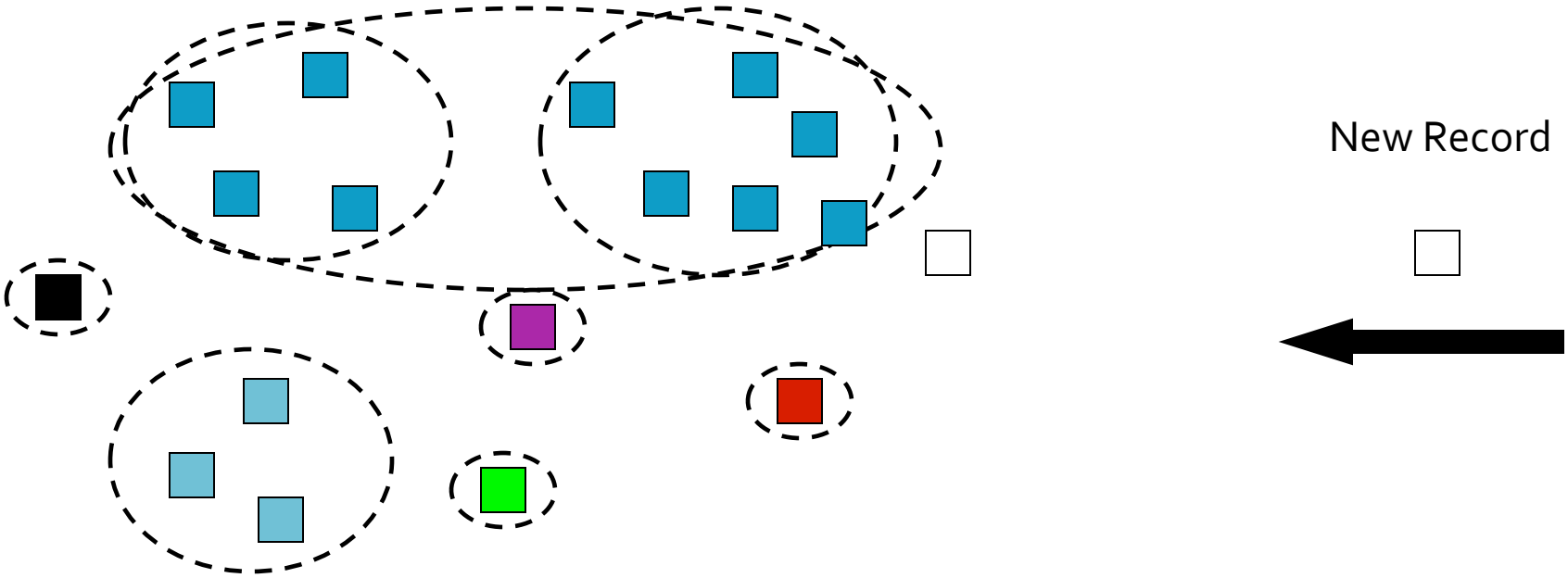
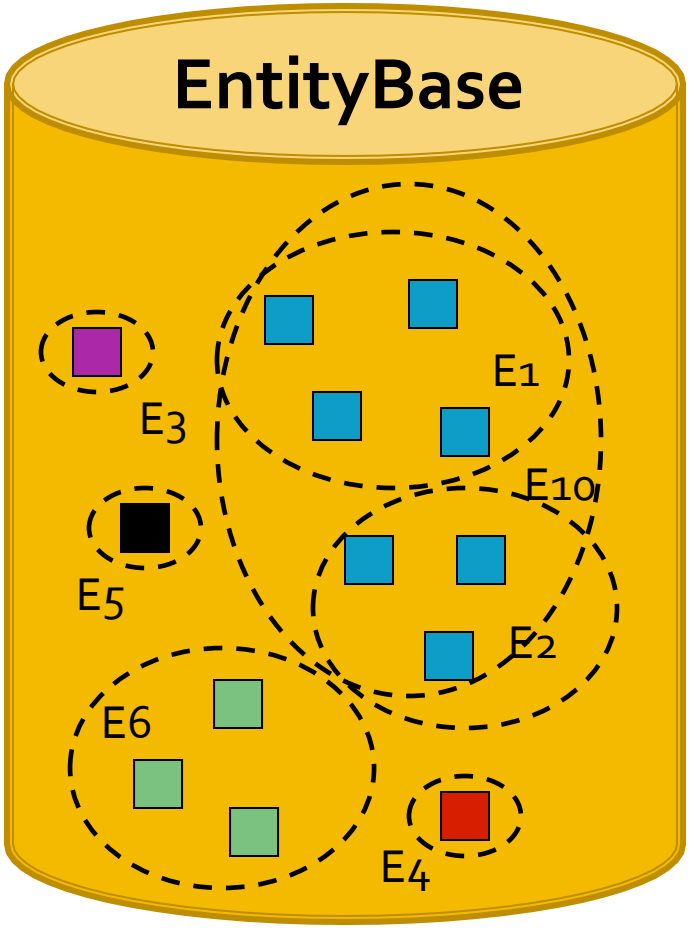


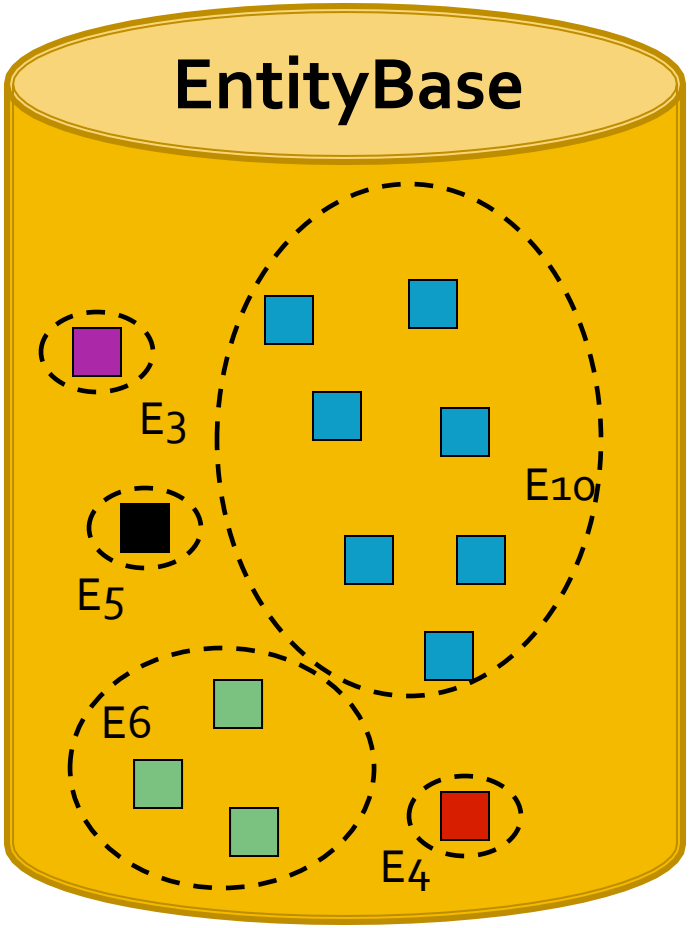
Correcting mistakes : Merging and splitting clusters

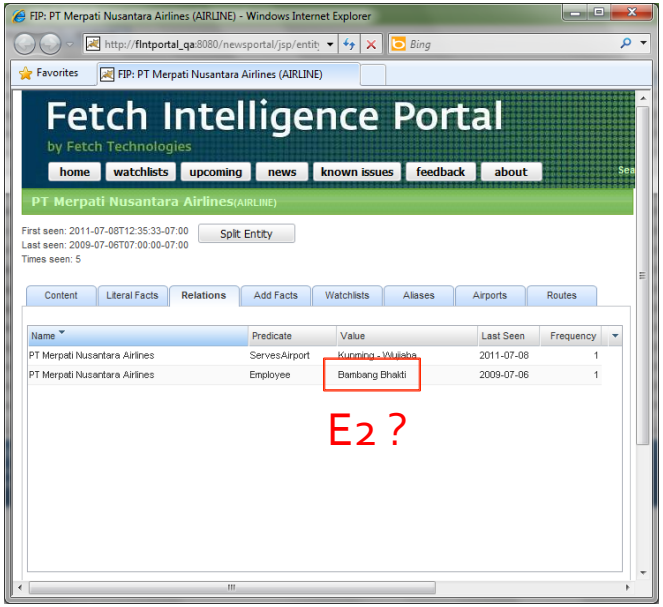
- Merge example:
  - Air Cess and Air Bas aircraft
- Split example:
  - George H. W. Bush and George W. Bush

Merging Two Clusters

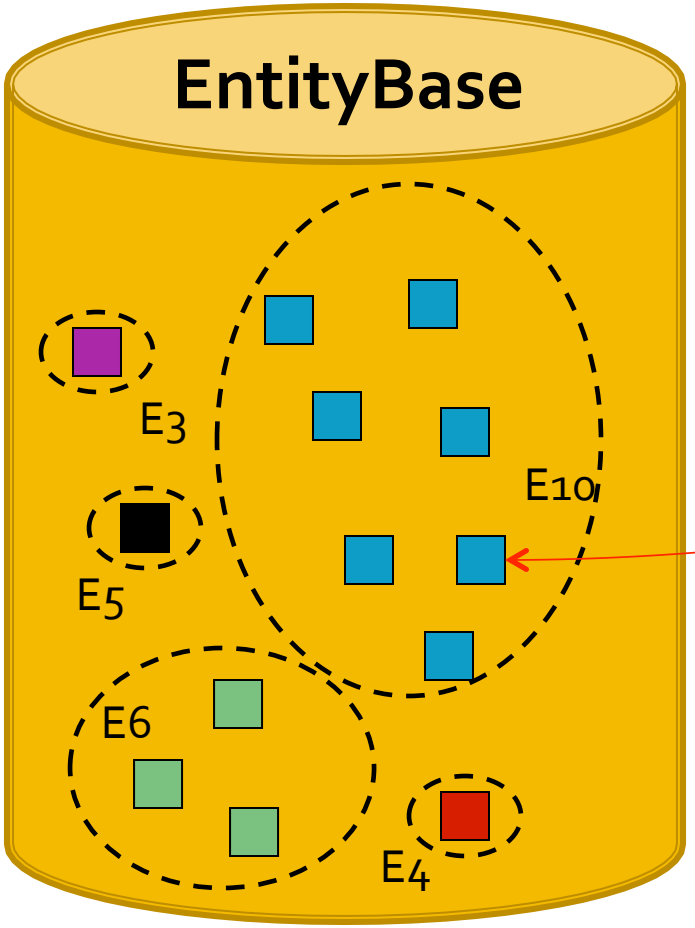


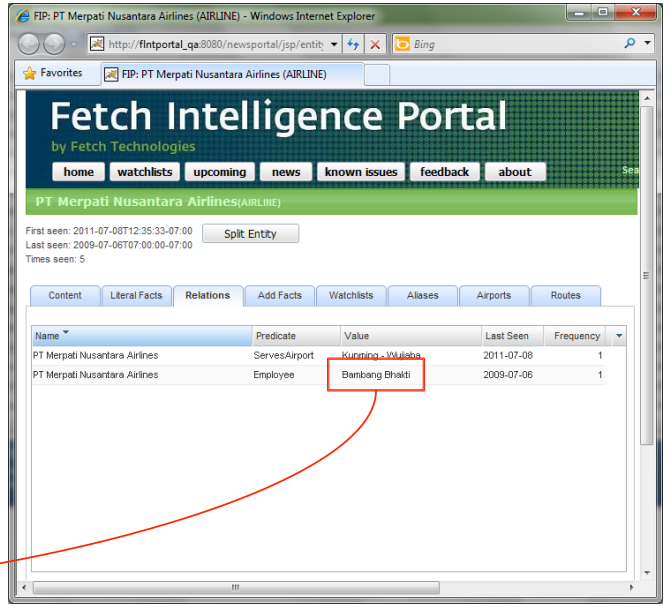
Referential Integrity



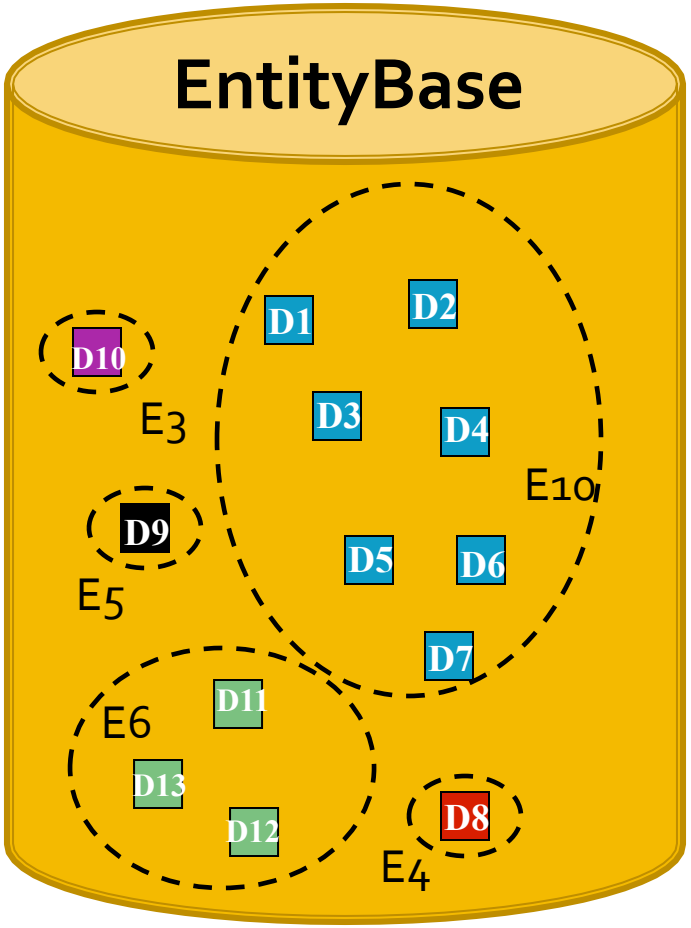


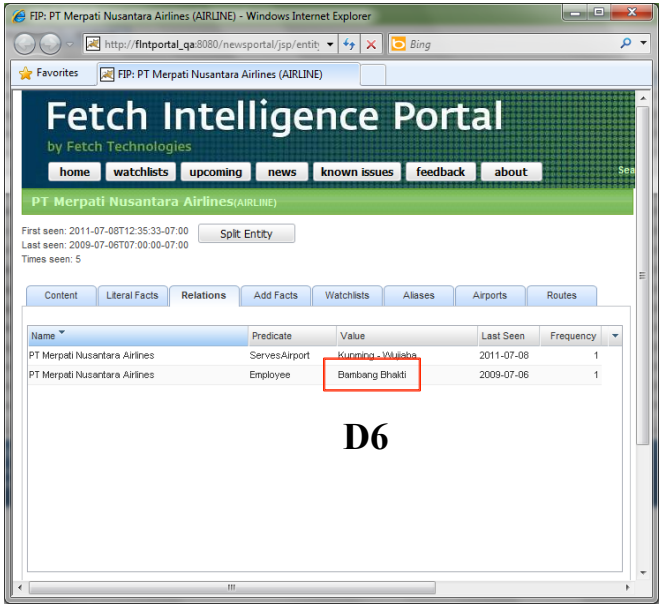
Refer-by-Description





Refer-by-Description





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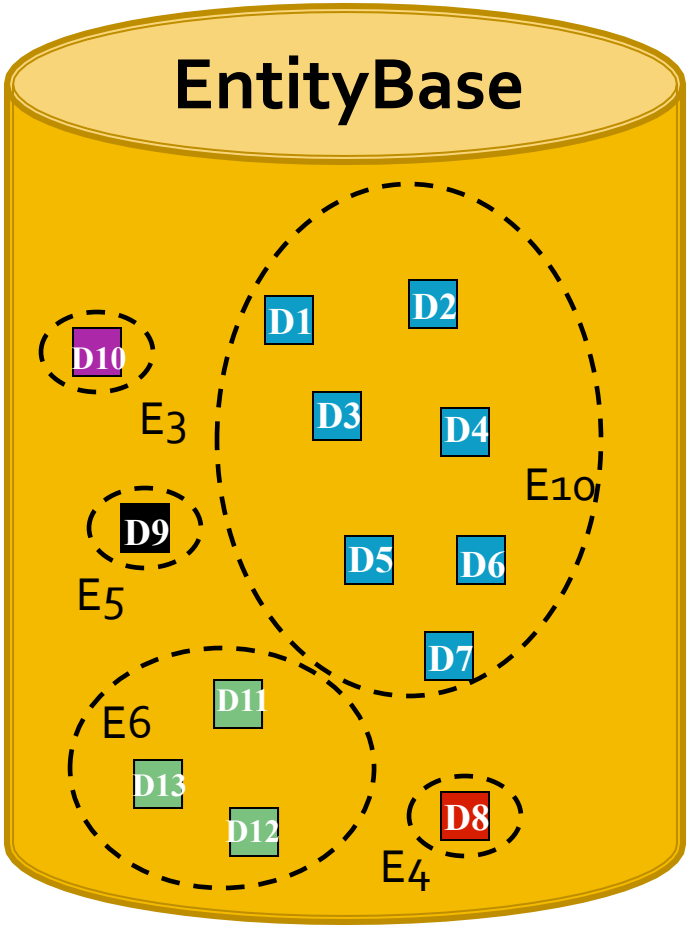
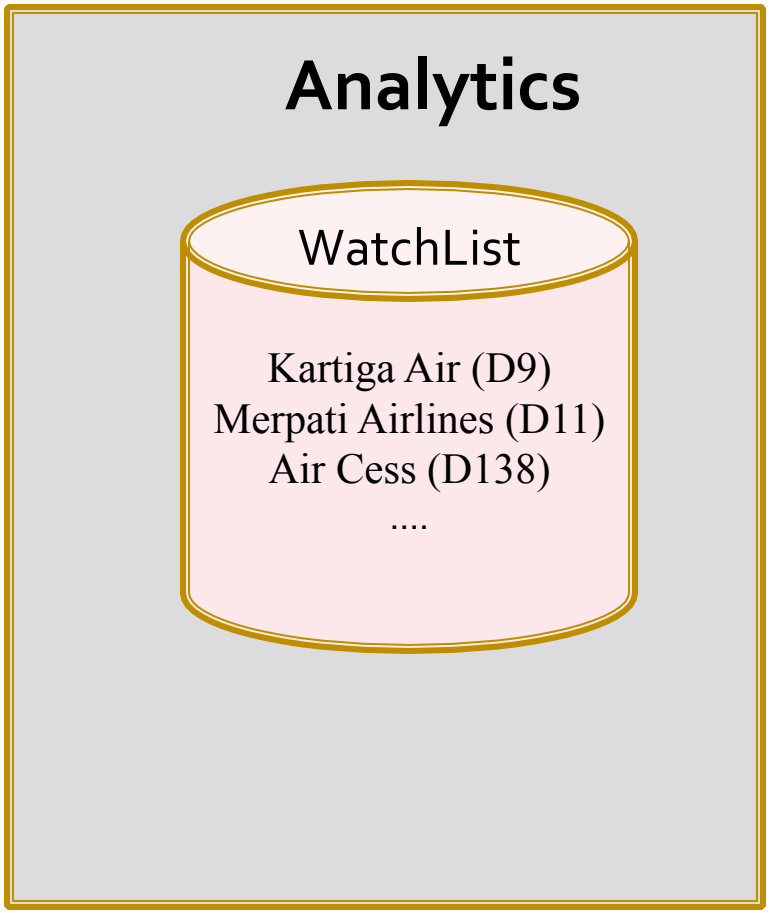
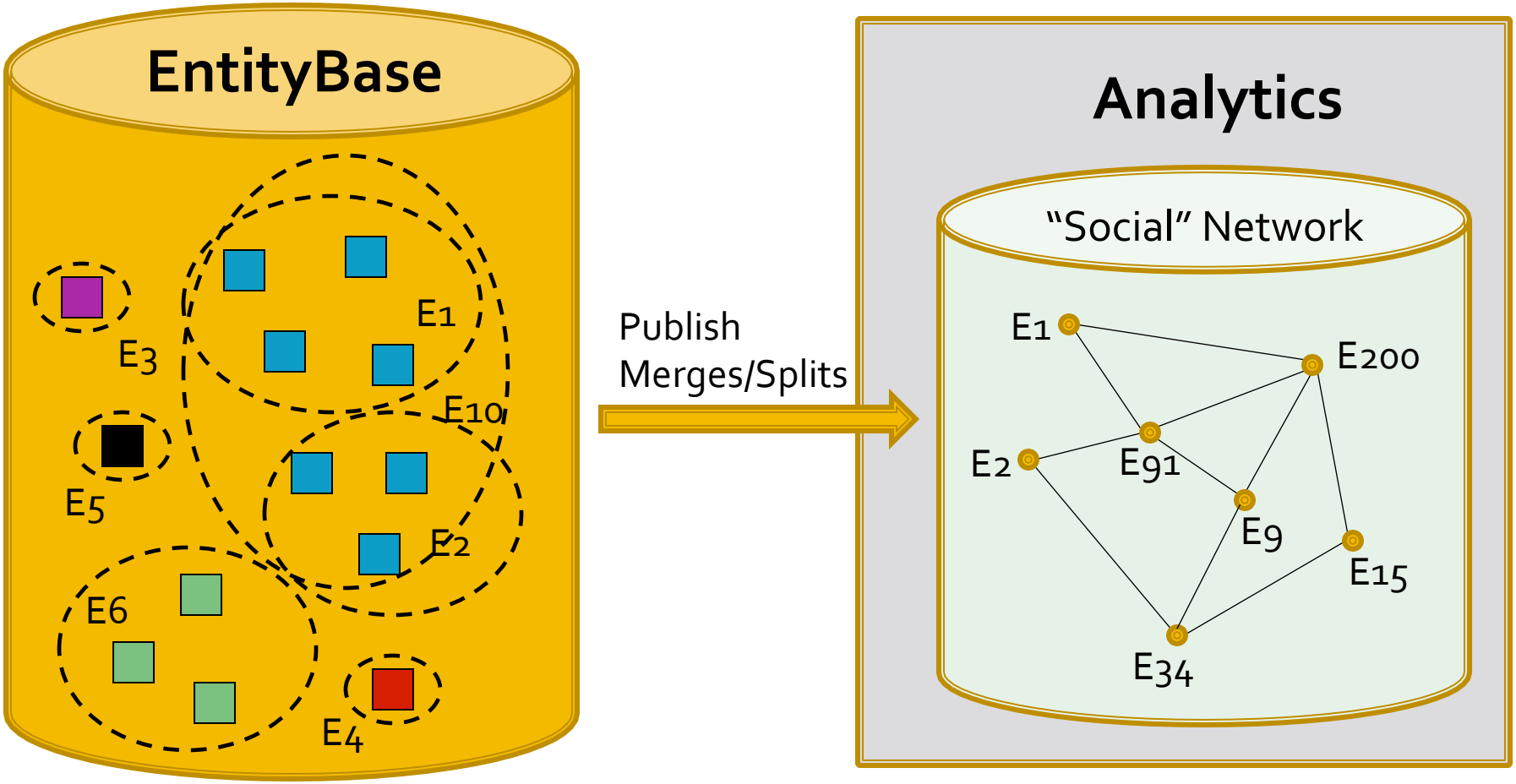
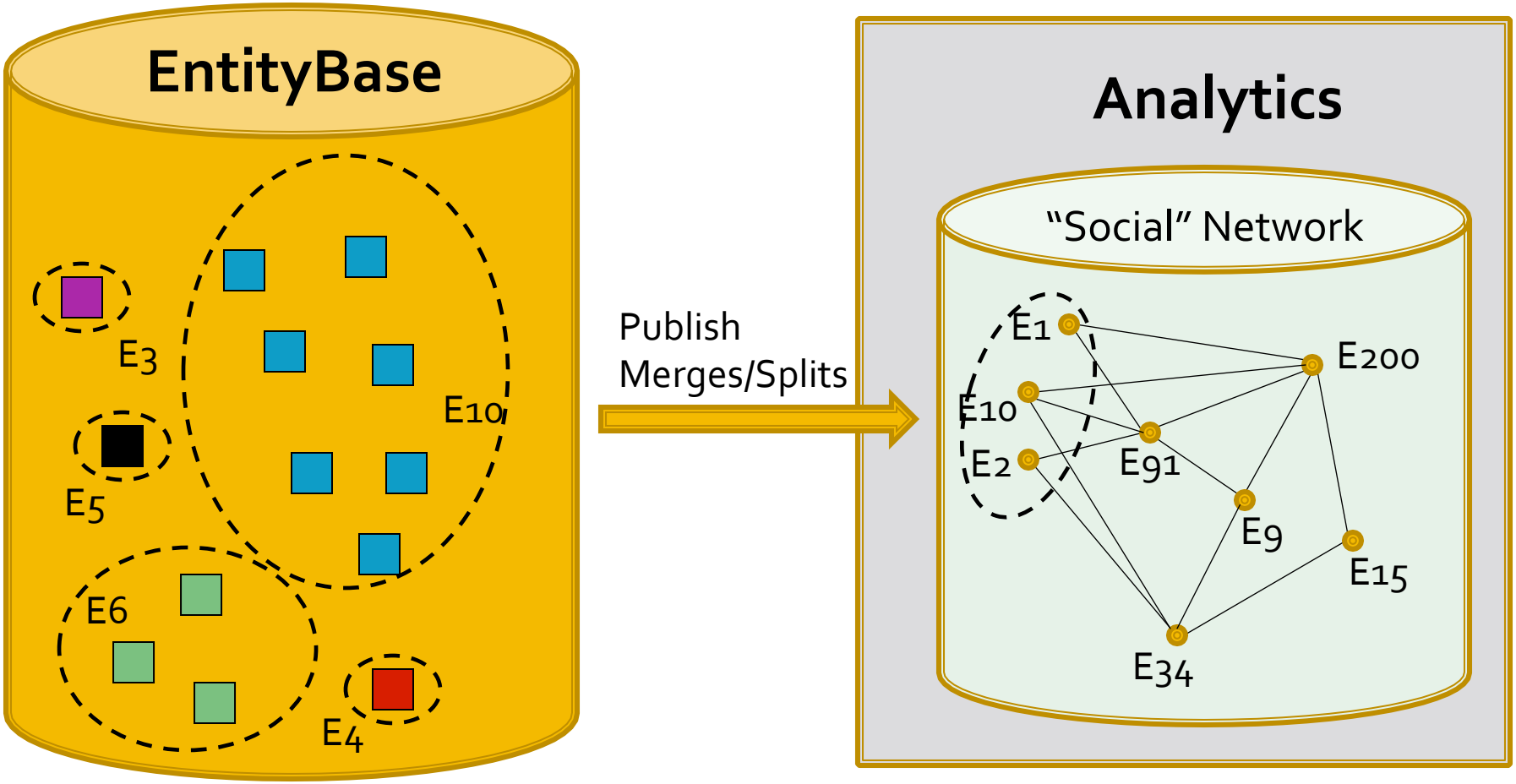




Refer-by-Identifier



Refer-by-Identifier



Maintaining Referential Integrity

- Two approaches:
  - Refer-by-Description
    - Indirect reference: Point to a cluster member
    - Advantage: Easy, no synchronization necessary
    - …But limits information that client can cache
  - Refer-by-Identifier
    - Direct reference: Cluster ID
    - Advantage: Client can cache arbitrary information
    - …But client must synch with EntityBase and maintain consistency

Why It Matters

- Vision: Entity Resolution in a decentralized world
  - E.g., the Semantic Web (Glaser, Jaffri & Millard, 2009)

Summary

- Entity resolution can be hard: "AI Complete"
  - Arms trafficking domain
- Entity merges and splits will occur
- Entity resolution clients must be designed to deal with this
- Two strategies: Refer-by-Description and Refer-by-Identifier
- System status: Being evaluated by AF personnel