



SellTrend: Inter-Attribute Visual Analysis of Temporal Transaction Data

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Looks Familiar?

The Expedia website interface features a blue header with the Expedia logo and navigation links: Home, Vacation Packages, Hotels, Cars, Flights, Cruises, Activities, DEALS & OFFERS, Maps, Business Travel, and Rewards. A search bar is located in the top right. The main content area is divided into three columns: 'Plan a Trip' with a 'NO FEES!' badge and a 'Search for flights + hotels' button; 'Save on Top Travel Deals' featuring a 'FREE NIGHTS WORLDWIDE' promotion; and 'Find Your Perfect Trip' with a world map and 'Explore by Destination' options.

The Orbitz website interface has a blue header with the Orbitz logo and navigation links: Quick Search, Vacation Packages, Hotels, Flights, Cars & Rail, Cruises, Activities, and Deals. A search bar is in the top right. The main content area includes a 'NO FEES!' badge, a '4-star hotels from \$99 a night' promotion, and a search form with fields for 'From', 'To', 'Leave', and 'Return'. A 'Find Flights' button is prominent.

This screenshot shows a travel search results page with a blue header and navigation links: Home, Vacation Packages, Flights, Hotels, Cars/Rail, Cruises, Last Minute Packages, Travel Deals, Activities, ExperienceFinder™, and Customer Support. The page is divided into several sections: 'The world is yours to travel' with a 'Sign in' link; 'Best Deals' featuring a 'Take a Real Vacation!' promotion; 'Why Book with Travelocity?' with a 'Price Guardian' guarantee; 'Book My Trip' with 'Save with Packages...' options; 'Pick Locations & Dates...' with a search form for ATL to CHI; and 'Add Traveler Info...' with a table for traveler counts. A 'Search' button is at the bottom right.

Adults (18-64)	Minors (2-17)	Seniors (65+)
1	0	0

Sort By: Price Duration Departure Time Arrival Time Airline

Airline	Departure Time	Arrival Time	Total Travel Time	Roundtrip Price includes taxes and fees	
 United Flight 283	6:40am Atlanta, GA (ATL)	7:44am Chicago, IL (ORD)	2hrs 4min - <u>Nonstop</u>  Flight #283 <u>on-time</u> : 92 %	\$198 per person Total \$219	No Flight Booking Fees! more
 Delta Air Lines Flight 1934	7:25am Atlanta, GA (ATL)	8:28am Chicago, IL (ORD)	2hrs 3min - <u>Nonstop</u>  Flight #1934 <u>on-time</u> : 100 %	\$198 per person Total \$219	No Flight Booking Fees! more
 Delta Air Lines Flight 1622	7:55am Atlanta, GA (ATL)	8:52am Chicago, IL (MDW)	1hr 57min - <u>Nonstop</u>  Flight #1622 <u>on-time</u> : 86 %	\$198 per person Total \$219	No Flight Booking Fees! more
 AirTran Airways Flight 30	8:20am Atlanta, GA (ATL)	9:11am Chicago, IL (MDW)	1hr 51min - <u>Nonstop</u>  Flight #30 <u>on-time</u> : 85 %	\$198 per person Total \$219	No Flight Booking Fees! more
 American Airlines Flight 1998	8:30am Atlanta, GA (ATL)	9:35am Chicago, IL (ORD)	2hrs 5min - <u>Nonstop</u>  Flight #1998 <u>on-time</u> : 95 %	\$198 per person Total \$219	No Flight Booking Fees! more Nonstop Service more

System Error

 **Sorry, we were unable to complete your request.**

Possible Causes:

- Session Expiration
- Use of Back or Stop button
- System Error

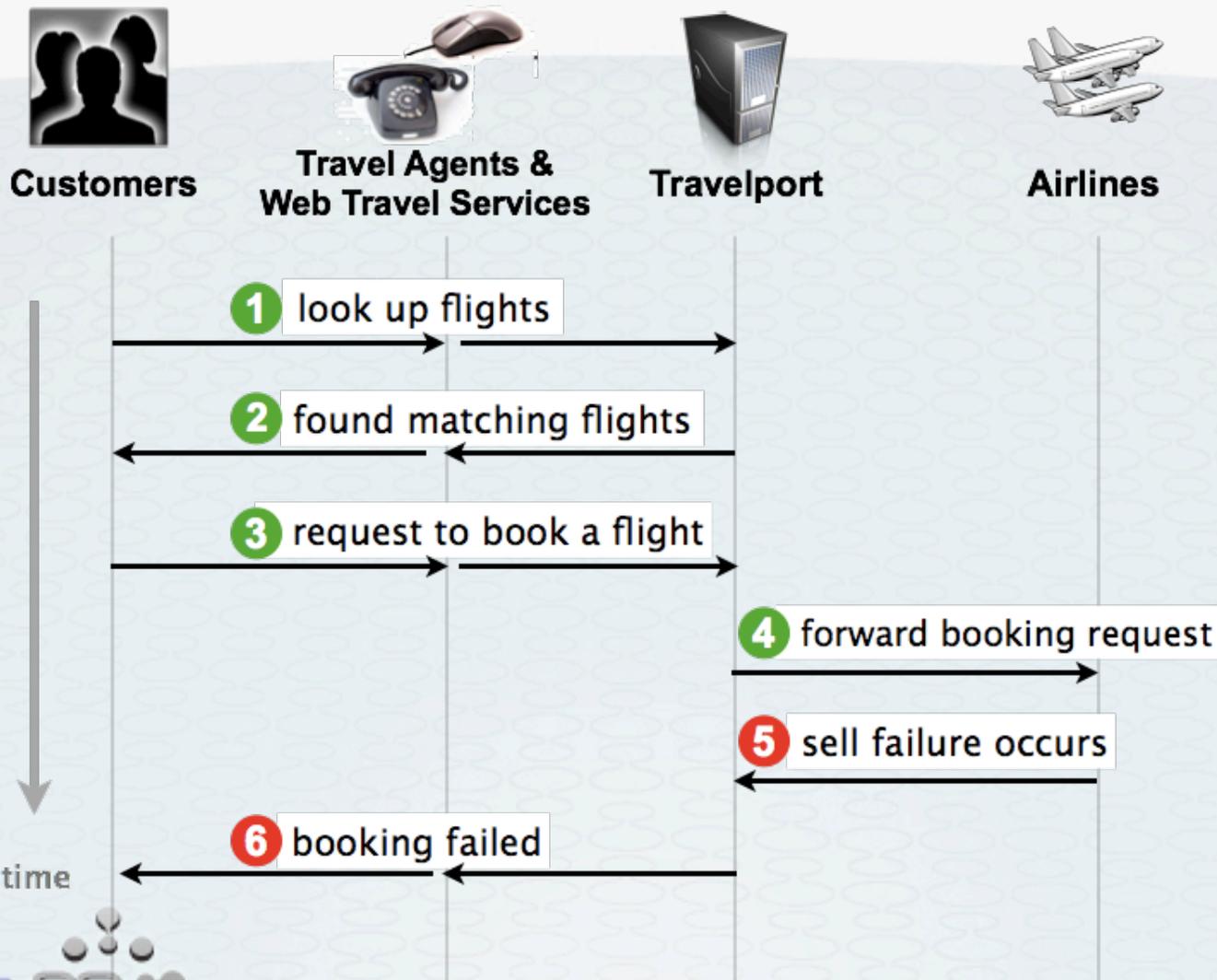
What you can do:

- Please try again.

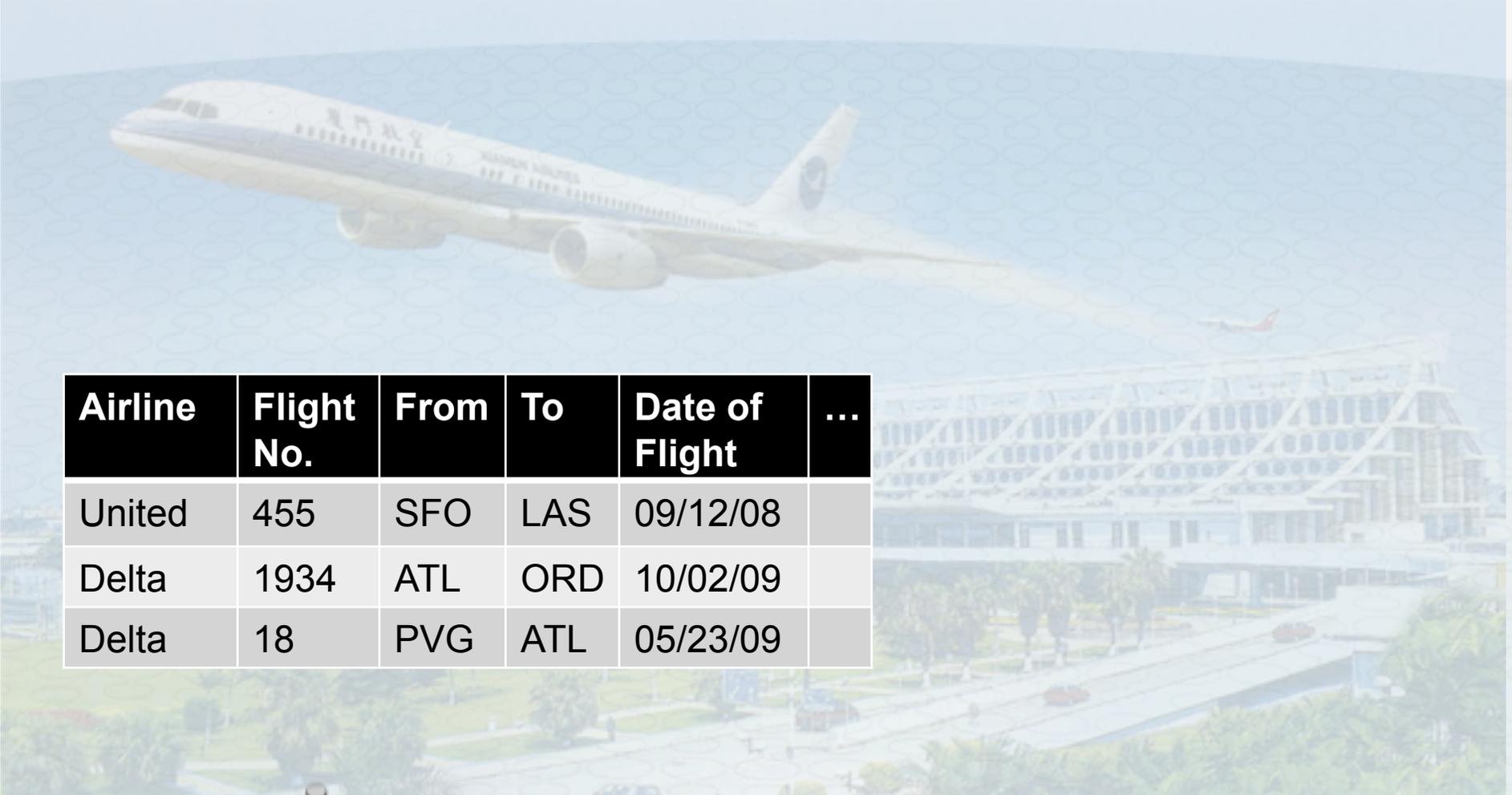
Travelport



Sell Failure



Attributes of Failed Transactions



Airline	Flight No.	From	To	Date of Flight	...
United	455	SFO	LAS	09/12/08	
Delta	1934	ATL	ORD	10/02/09	
Delta	18	PVG	ATL	05/23/09	

Attributes of Failed Transactions

Airline	Flight No.	From	To	Date of Flight	...	Travel Agent	Date of Transaction	Error Code	...
United	455	SFO	LAS	09/12/08		DFG	09/01/08	420	
Delta	1934	ATL	ORD	10/02/09		XLK	09/20/09	421	
Delta	18	PVG	ATL	05/23/09		POS	03/25/09	200	

Causes of Failure

- Inventory volatility: expected
- A travel agent may deploy new software that performs availability queries incorrectly
- Agents use the Travelport system in an inefficient manner
- Internal system errors

ANOMALY

Anomalous causes can consist of

- A single attribute value, e.g. an airline, or
- Any combination of any number of the attribute values

Difficulty of Analyzing

Current tools do not support in-depth analysis well

- Lack of real-time situational awareness
- Anomaly detection is not simply identifying top contributors
 - Often requires historical trending analysis

Huge data and search space

- Many millions of failed transactions stored for the latest 40 days
- ~20 attributes, up to thousands of values within an attribute
- Anomaly can be any combination of any number of attribute values: impossible to enumerate all possibilities

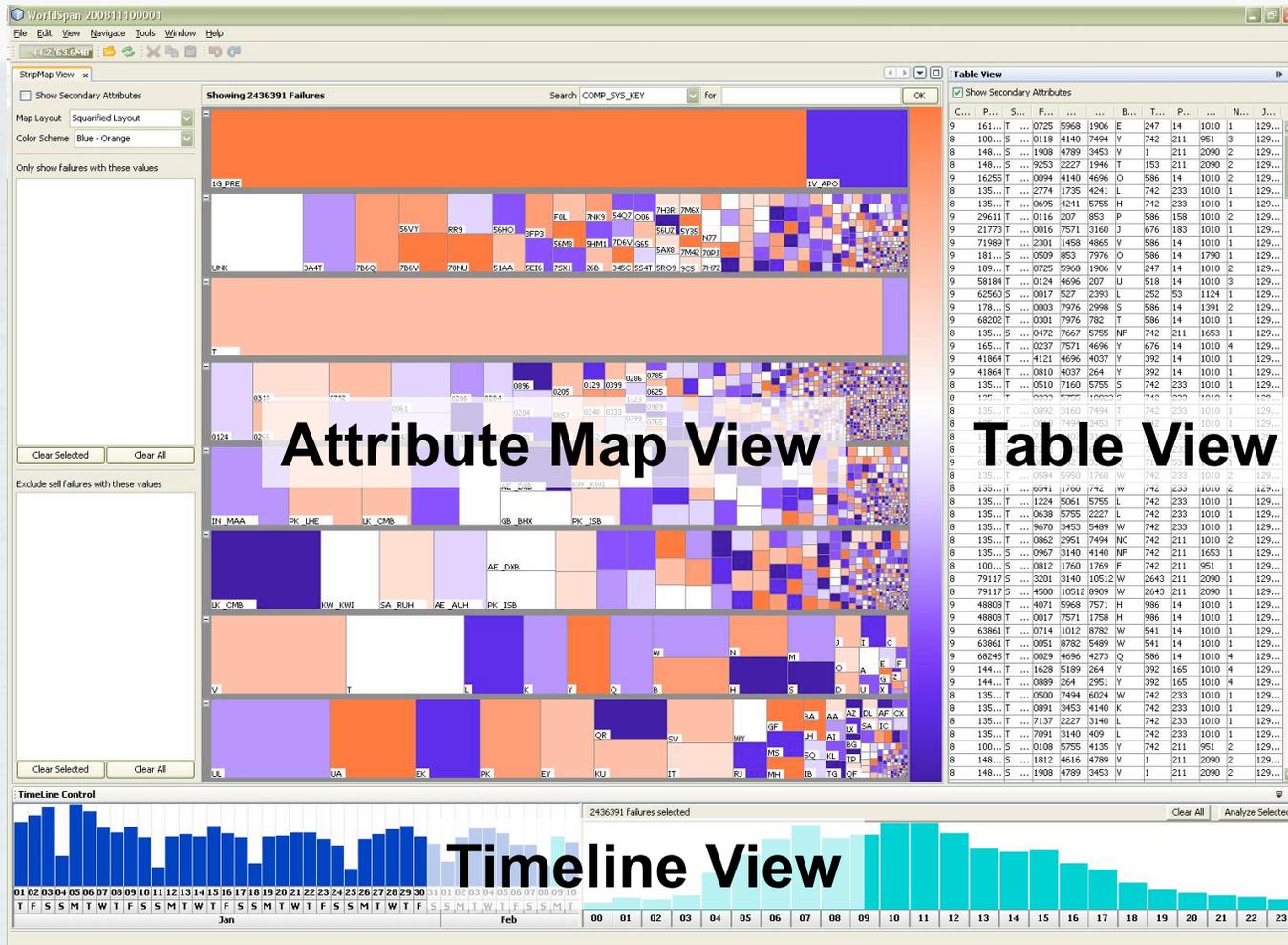
Analytic Tasks to Design for

- Enable Situational Awareness
 - What is the failure rate for the past hour?
 - How is today's failure rate compared to yesterday and one month ago?
 - Are any attribute values contributing irregularly high failed transactions presently?
- Support Exploratory/Investigative Analysis
 - What are the root causes of a failure spike?
 - Can these root causes be explained by potentially anomalous behaviors of relevant stakeholders?

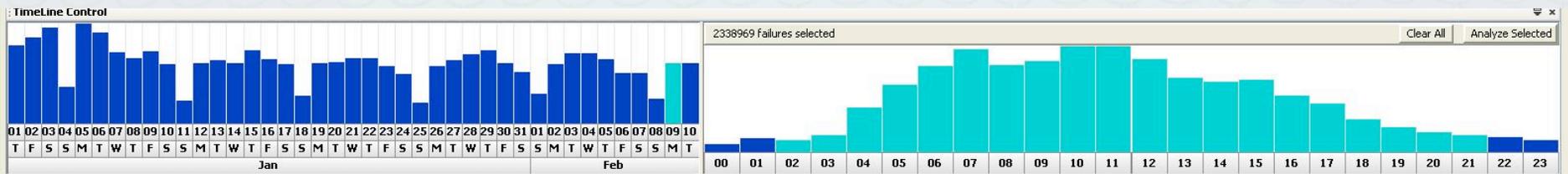
User-Centered Design

- Spreadsheet prototype to deployment over corporate database
- Formative Evaluation

SellTrend



Timeline View



Day Panel

Hour Panel

Attribute Map View



- ← Travel agent
- ← AVL Type
- ← Sell Type
- ← Error Code
- ← Flight Number
- ← Departure City
- ← Arrival City
- ← Flight Class
- ← Airline

Attribute Map View – A Closer Look

Analysis time frame: Oct 8th,

No. of failed transactions: **10,000** on that day

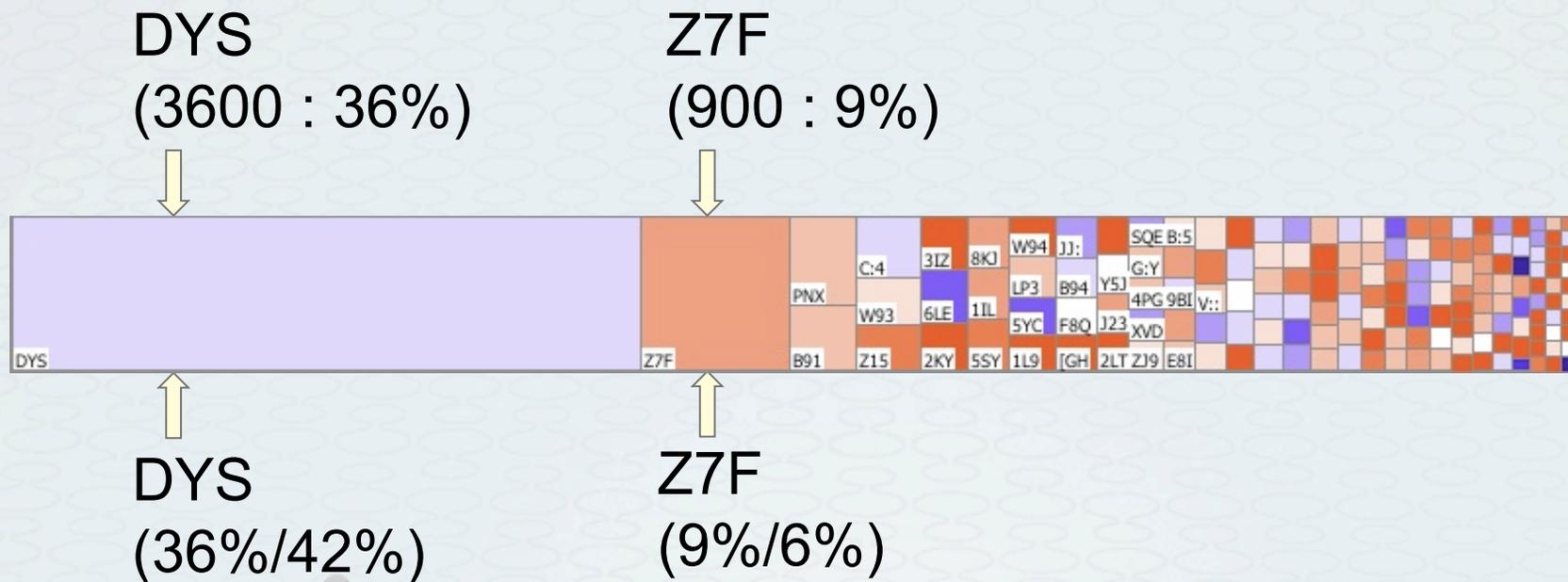


Table View

Show Secondary Attributes

SID	AVL TYPE	SELL TYPE	ERROR CODE	FLIGHT NUMBER	BOARD POINT	OFF POINT	CLASS	VENDOR
P1S	+++	FD	313	539	ILH	JDO	W	A101
P1S	+++	FD	0	152	JDO	MBY	W	A101
L7V	EBB	EB	0	539	ILH	JDO	W	A101
L7V	EBB	EB	314	152	JDO	MBY	W	A101
J23	EBB	EB	0	273	QWH	JDO	W	A101
J23	EBB	EB	313	166	JDO	KGL	W	A101
7Z2	+++	FD	313	539	ILH	JDO	F	A101
FKL	+++	NBO	307	452	TQO	JDO	J	A101
JJX	BWT	BWM	314	434	OSU	TWP	I	A117
JJX	BWT	BWM	314	335	TWP	DEH	I	A117
JJX	BWT	BWM	314	434	OSU	TWP	I	A117
JJX	BWT	BWM	314	335	TWP	DEH	I	A117
JJX	BWT	BWM	314	434	OSU	TWP	I	A117
JJX	BWT	BWM	314	335	TWP	DEH	I	A117
VM4	BWT	BWM	313	400	EFM	TWP	N	A117
VM4	BWT	BWM	313	478	TWP	LJO	N	A117
FZB	EBB	EB	314	445	ILH	TWP	U	A117
FZB	EBB	EB	314	160	TWP	DQI	U	A117
6ID	+++	Y"1	314	54	MJN	DV[O	A80
PI7	EBB	EB	313	128	PLB	JDO	X	A101
PI7	EBB	EB	0	151	JDO	MBY	X	A101
PXI	+++	Y"1	313	98	GVL	JDO	L	A101
DYS	+++	FD	313	763	JDO	OSU	R	A101
DYS	+++	FD	313	763	JDO	OSU	R	A101
DYS	+++	FD	313	763	JDO	OSU	Z	A101
DYS	+++	FD	313	763	JDO	OSU	Z	A101
DYS	+++	FD	313	763	JDO	OSU	Z	A101
DYS	+++	FD	313	763	JDO	OSU	R	A101
J4Z	EBB	EB	313	523	JDO	NOM	I	A101
7Z2	+++	FD	313	539	ILH	JDO	F	A101
J23	EBB	EB	0	273	QWH	JDO	W	A101
J23	EBB	EB	314	166	JDO	KGL	W	A101
6NP	EBB	EB	314	140	CFZ	PUQ	Z	A109
PBU	BWT	BWM	314	610	PNT	TWP	X	A117
F5Y	+++	Y"1	314	381	MJN	NJB	R	A80
Y2S	BWT	BWM	313	763	JDO	OSU	I	A101
RVV	EBB	EB	314	78	JDO	OSU	T	A101
P1S	+++	FD	313	539	ILH	JDO	W	A101

Demo

Related Work

- Time Series Data Visualization
 - Bar chart, color encoding of temporal change
- Categorical Data Visualization
 - Parallel Sets, InfoZoom, Pixel Bar Chart, EZChooser
- Faceted Browsing
 - Flamenco, FacetMap, FacetLens

Design Considerations

- Event-based Coordination between the Views
- Simple Visual Representation Consistent with Users' Mental Model
- Direct Manipulation Facilitates Cognitive Coupling
- High Interactivity and Prompt Feedback

Progress

SellTrend has been deployed since Dec 2008

“The data visualization tool provides [us] the ability to analyze potentially millions of rows of data at a customer and/or supplier level in a single ‘view’. By reducing this initial investigation time frame by greater than 90%, we can more quickly direct our resources to the underlying sell failure root cause. Addressing sell failure issues in a timelier manner improves our product quality, improves the customer experience, and provides a more efficient use of Travelport staff.”

--- a company analyst

Contributions

- Synthesizing temporal and categorical visualization techniques for a problem domain
- Approach can be generalized for similar datasets to identify interesting combinations and relationships between attribute values in user-defined time ranges
- A case study of successfully applying visualization techniques to a real world challenge on huge datasets with considerable complexity

Thank You.

Questions?

This research is supported in part by



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