

# Generating Product Traceability Trees for Harvesting from GPS Tracks

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## Motivation

- Product traceability is crucial for risk management
- It is troublesome for farmers to maintain records required by high-precision product traceability during harvesting
- Resulting records are normally far away from user-friendly

## Background for Wheat Harvesting

- Multiple vehicles may work cooperatively
- Vehicle types: combine harvesters, grain carts, and trucks

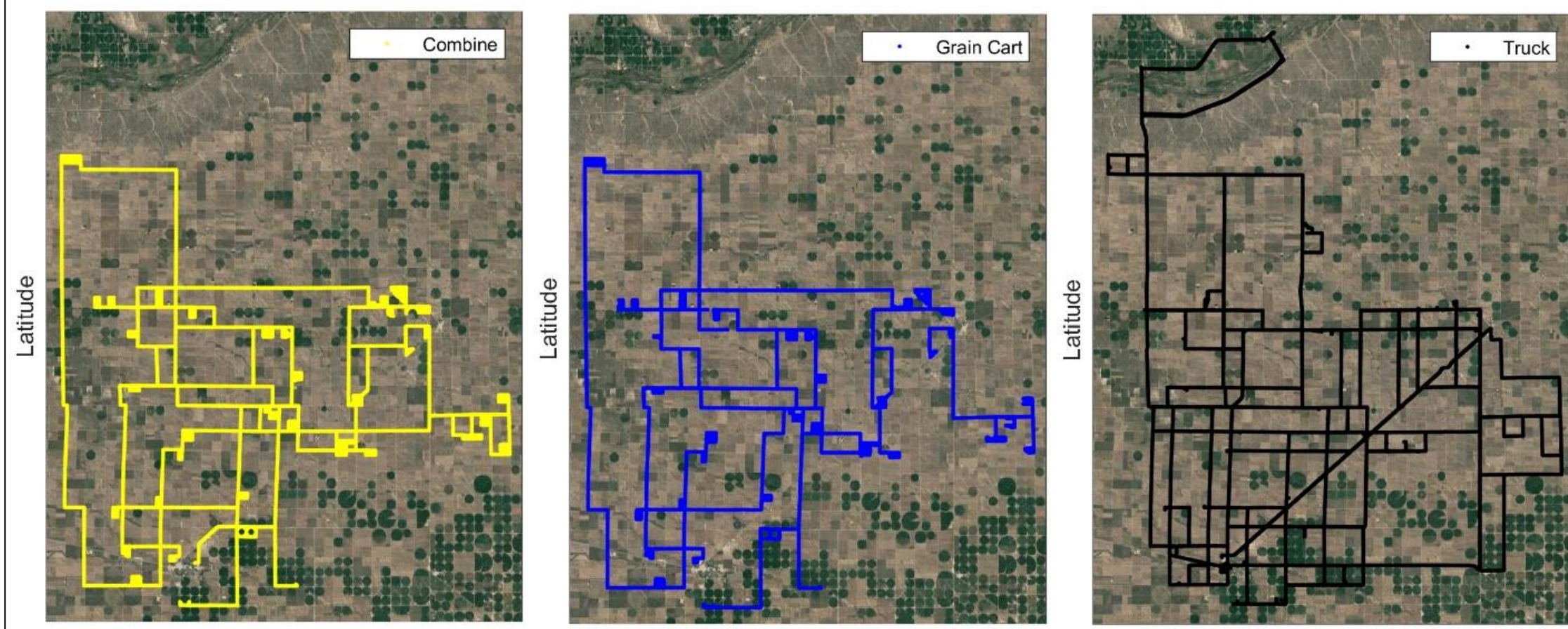


Figure 2. Overview maps for the 2017 GPS dataset



Figure 3. Illustrations for wheat harvesting

## Product Traceability Tree Design

- A unified way of organizing harvesting, unloading & loading between vehicles, selling at elevators, storing at barns, and any other transfer event if necessary
- Tree data structure is utilized for its advantages in data storage and visualization
- Transfer event locations are represented by GPS samples, recorded by relevant transfer event nodes
- Our system builds trees in a bottom-up approach

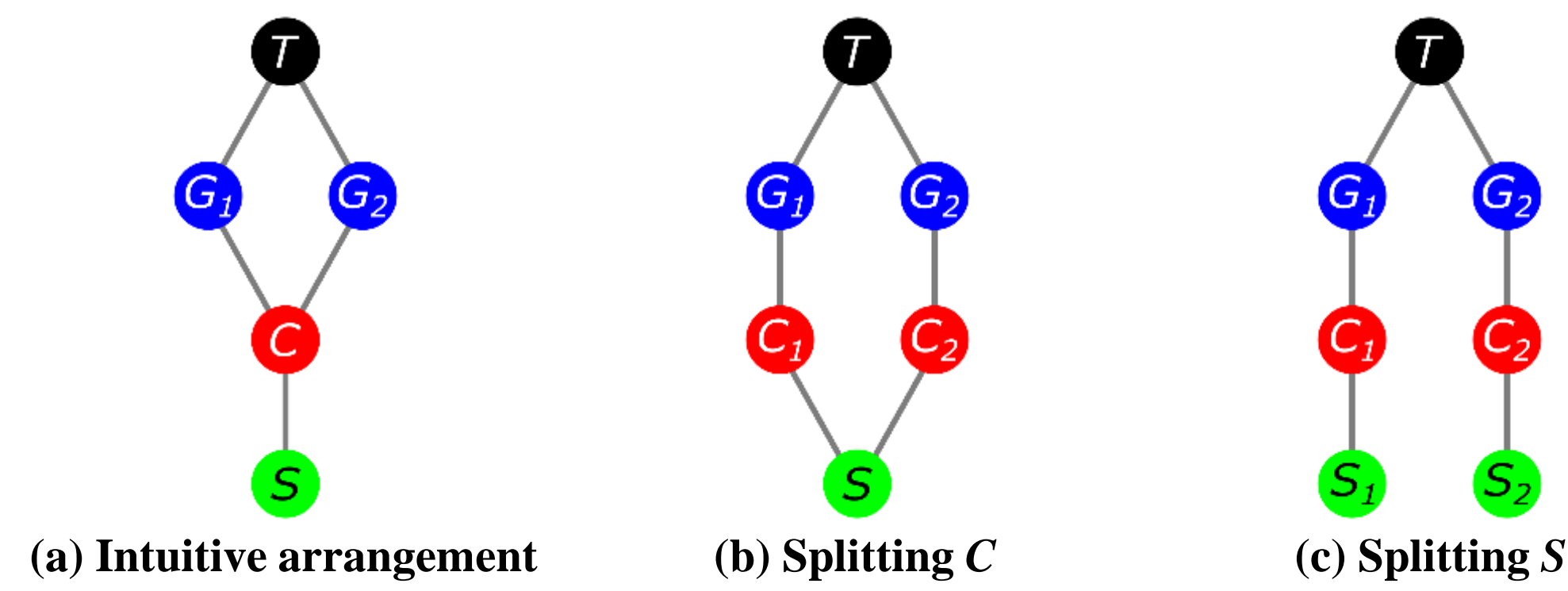


Figure 4. Illustrations for wheat harvesting

## An Event-Driven Traceability System

- Transfer events are recognized by our previous work<sup>[c]</sup>
- The product traceability tree builder is responsible for transferring events into a tree data structure for storage
- The visualization subsystem takes care of plotting the tree and responding to user interactions

vehId	type	event	idFrom	idTo	estTimeStart	estTimeEnd	vehFileId	fileIdFrom	fileIdTo	estGpsTimeStart	estGpsTimeEnd
p.e.7130	Combine	u2h	p.e.7130	p.and.e.290	7/1/2017 13:12	7/1/2017 13:13	239	239	233	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	u2h	p.and.e.6130	p.and.e.290	7/1/2017 13:17	7/1/2017 13:18	243	243	233	1.48893E+12	1.48893E+12
p.e.7130	Combine	u2h	p.and.e.290	p.e.7130	7/1/2017 13:23	7/1/2017 13:23	239	239	233	1.48893E+12	1.48893E+12
p.and.e.290	Grain Kart	u2t	p.and.e.290	p.and.e.100	7/1/2017 13:24	7/1/2017 13:25	239	239	203	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	h	Fields	p.and.e.6130	7/1/2017 13:28	7/1/2017 13:28	243	0	243	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	h	Fields	p.and.e.6130	7/1/2017 13:28	7/1/2017 13:29	243	0	243	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	h	Fields	p.and.e.6130	7/1/2017 13:29	7/1/2017 13:29	243	0	243	1.48893E+12	1.48893E+12
p.e.7130	Combine	h	Fields	p.e.7130	7/1/2017 13:29	7/1/2017 13:29	239	0	239	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	h	Fields	p.and.e.6130	7/1/2017 13:29	7/1/2017 13:54	243	0	243	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	u2h	p.and.e.6130	p.and.e.290	7/1/2017 13:32	7/1/2017 13:33	243	243	233	1.48893E+12	1.48893E+12
p.e.7130	Combine	u2h	p.e.7130	p.and.e.290	7/1/2017 13:36	7/1/2017 13:41	239	239	233	1.48893E+12	1.48893E+12
p.and.e.6130	Truck	u2t	p.and.e.6130	p.and.e.100	7/1/2017 13:48	7/1/2017 13:50	243	203	203	1.48893E+12	1.48893E+12
p.and.e.6130	Combine	h	Fields	p.and.e.6130	7/1/2017 13:54	7/1/2017 14:37	243	0	243	1.48893E+12	1.48893E+12
p.e.7130	Combine	u2h	p.e.7130	p.and.e.290	7/1/2017 13:55	7/1/2017 13:57	239	239	233	1.48893E+12	1.48893E+12

Figure 5. Automatically-generated event list

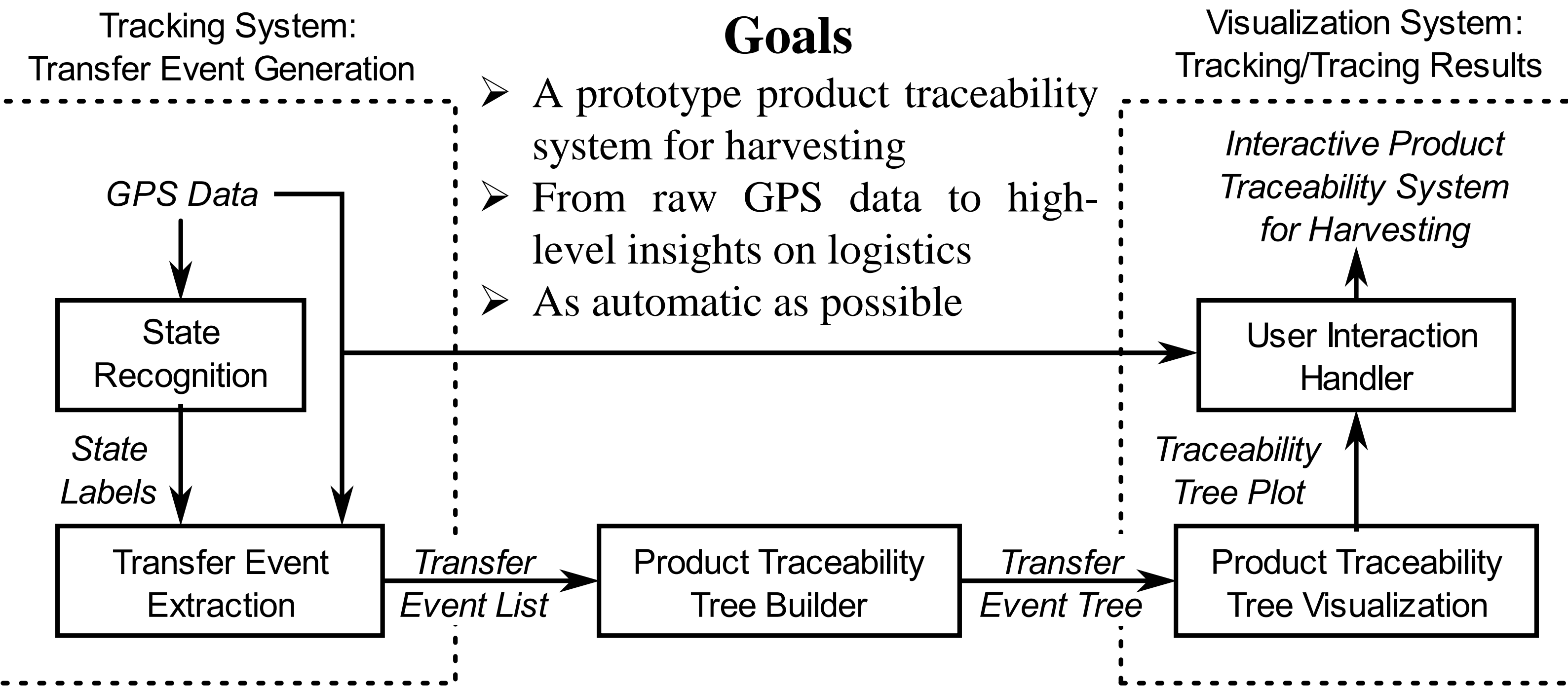


Figure 1. Overview for the prototype traceability system

A fully-automatic algorithm<sup>[a]</sup> to build product traceability trees for harvesting via GPS tracks<sup>[b]</sup>.

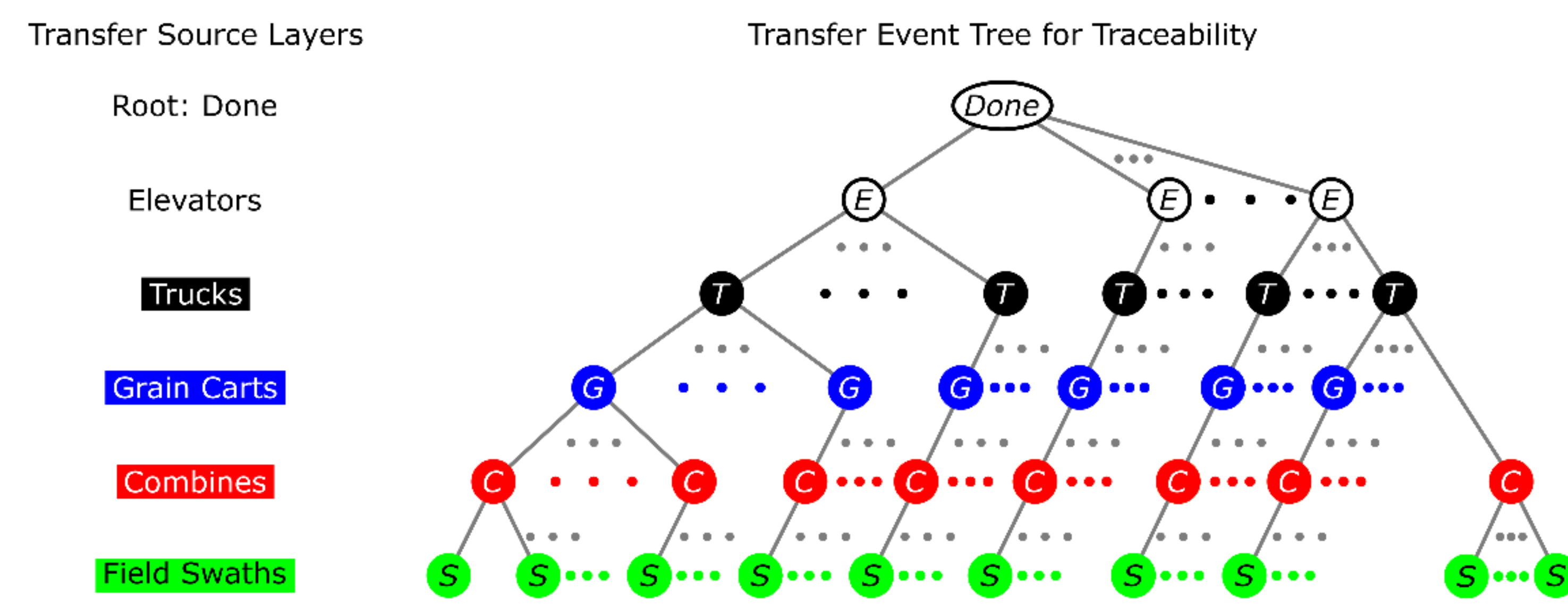


Figure 6. Designing a product traceability tree for visualizing all transfer events

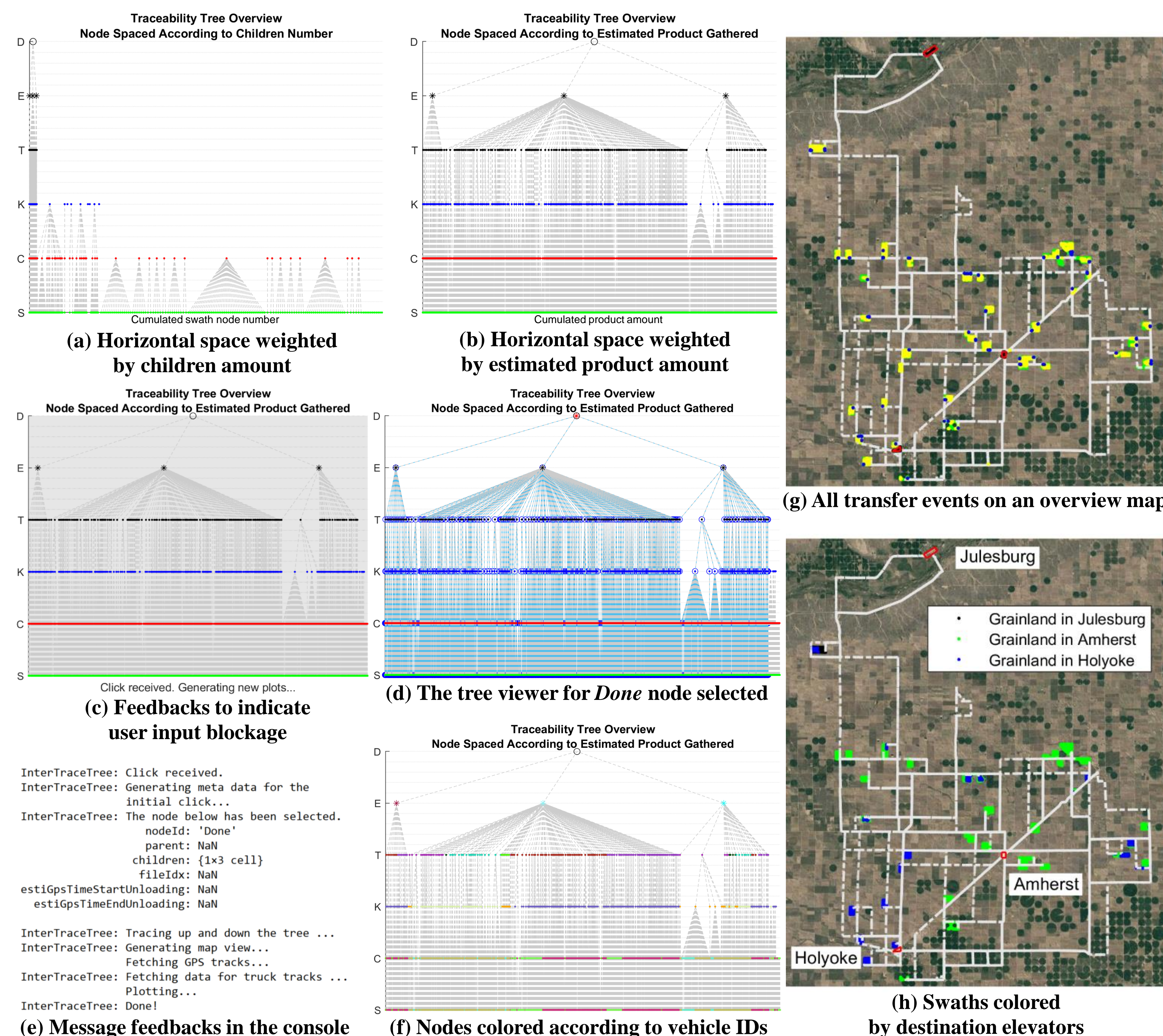


Figure 7. The interactive visualization system

<sup>[a]</sup> Implemented using Matlab. More about Matlab at: <https://www.mathworks.com/products/matlab.html>  
 Matlab code available at: <https://github.com/YaguangZhang/GpsDataVisualizationAndAnalysisWorkspace.git>  
<sup>[b]</sup> We have been collecting GPS data during wheat harvesting seasons using an Android app we developed. Android code available at: <https://github.com/OATS-Group/CombineKartTruck.git>  
<sup>[c]</sup> More details in "Zhang, Y., Ault, A., Krogmeier, J. V., & Buckmaster, D. (2017). Activity Recognition for Harvesting via GPS Tracks. In 2017 ASABE Annual International Meeting (p. 1). American Society of Agricultural and Biological Engineers".

## Discussion

- The prototype system is low-cost and easy-to-implement
- Accuracy has been traded for high-level automation
- Traceability could be improved with more automatically-generated data, e.g. CAN bus messages

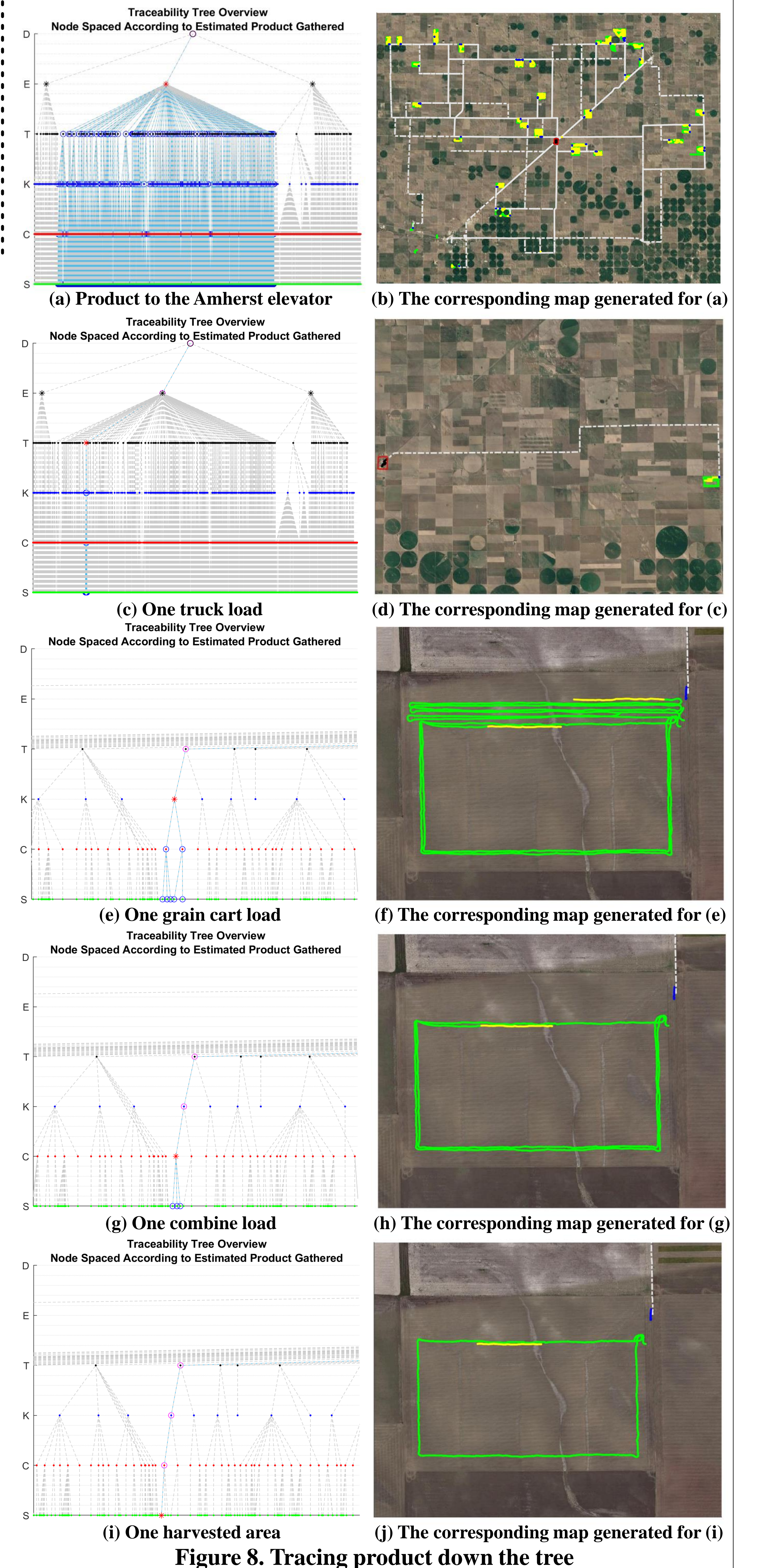


Figure 8. Tracing product down the tree

## Conclusion

- A fully-automatic algorithm is proposed to efficiently build product traceability trees for wheat harvesting
- A prototype traceability system has been implemented to illustrate the potential of these product traceability trees

## Acknowledgements

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