CBTS: Using Dogs to Detect Contraband in Shipping Containers

Source: CBTS

What do dogs, timber, and cotton pads all have in common? They are all part of CBTS's latest project in partnership with the University of Washington and Dr. Sam Wasser to create a low-cost, high throughput method using dogs to detect contraband in shipping containers.

Since 1973, Dr. Wasser has worked in Africa, focusing on illegal wildlife trade and poaching. His work with elephant poaching began by pioneering methods to extract DNA from feces, creating a DNA map of elephants across Africa. He then developed tools to extract DNA from elephant tusks in large ivory seizures. Dr. Wasser wanted to determine from where and from which elephants this ivory was being poached, so he compared the DNA extracted from elephant tusks to the DNA reference map he created from dung. Around the same time, he developed dog detection methods to find fecal samples from a variety of species over large remote areas. As Dr. Wasser's work progressed, it became clear that major wildlife traffickers were capitalizing on the large volume of legal maritime containers moving around the world. They are concealing their contraband among the one billion maritime containers (measures in twenty-foot equivalent units—TEUs) moving around the world annually. Better, less conspicuous methods were needed to inspect these shipments with minimal disruption on port operations. These findings led Dr. Wasser to us his experiences and advances to find ways to rapidly search containers for illegal fauna and flora, in collaboration with CBTS.

Contents

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CROSS-BORDER THREAT SCREENING AND SUPPLY CHAIN DEFENSE
A Department of Homeland Security Center of Excellence

TEXAS A&M AGRILIFE

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To rapidly search the containers, Dr. Wasser created a method that inconspicuously captures odors from the air within the container. A small and highly portable device is used to vacuum the air out of the container vent, without breaking customs seals. Containers can even be searched while still stacked. Within this device is a widely available, inexpensive cotton pad that captures the specific odor of the illegal species. The cotton pad is removed and presented to the dogs outside of public view, who then alert their handler to the pads that have the illegal contraband odor. It is important that this method is minimally disruptive as many ports are moving thousands of shipments daily and wouldn't be able to work efficiently with every container being searched.

Phase 1 of the project with CBTS focused on proving the concept. First, he had to determine what contraband should be the focus of the study. As there are not very many ivory seizures in the United States, he ultimately settled on illegal species of timber. Twenty-five percent of all timber enters a U.S. port at some point. Initial trials took place on legal timber species, providing numerous opportunities to test the method before they could even begin testing the illegal species. They started with a legal species that are being shipped frequently enough to allow the dogs a good chance to detect these wood products coming through the ports. They used this phase to answer questions such as: what is the minimum time to vacuum out enough air for the dogs to reliably detect the target odor? What's the smallest amount of target odor that a dog can detect? Can the dog detect target odor mixed with other non-target materials? How does the cotton pad compare to other odor capture materials?

Phase 2 is where Dr. Wasser's team plans to implement this method at different ports. However, they first had to find the right port to do so. The Sumas port offered the ideal location for this as 65% of all timber entering the US pass through this port. Every 4th container has wood and offers a large variety of shipment mixtures for them to test the dog's ability to detect target species when mixed with other wood species and products. Phase 2 also aims to test the method at other ports, including illegal timber passing through the Port of Houston and illegal ivory, pangolins, rhino horn and abalone passing through ports in South Africa.

Overall, the success of this project would have many benefits for the Department of Homeland Security – Homeland Security Investigations and Customs and Border Protection. As Dr. Wasser said, "we are desperate for better tools to detect contraband coming into and out of the port" and currently, there aren't many discreet methods to search these containers that also still allow a port to continue to function normally. In addition, working overseas allows us to push our borders further away from the United States to identify problems before they arrive on our shores. Successfully addressing timber alone would yield great benefits in combating crime and in protecting our environment. Transnational criminal organizations make around $50-150 billion dollars/year of profit on illegal timber, and the overall impact is closer to $1 trillion dollars when the illegal harvesting and deforestation impacts to climate change are considered. Over time, there may be an increase in which species become endangered and illegal to harvest. Catching trafficked illegal timber early will prevent massive problems going into the future. Further, once these methods are expanded to other illegal species and trafficked wildlife, it will be a game changer in the number of containers investigated and the amount of trafficked goods seized.

Traceability for 21st Century Trade: Distributed Credential Capture and Secure Logging

Source: TAMU Agrilife

Blockchain for business was all the buzz several years ago, and the Cross Border Threat Screening and Supply Chain Defense Center of Excellence (CBTS) was ready to answer research questions with this technology. Blockchain offers hallowed immutability and was often touted in public discourse as a cure-all for traceability. Numerous consumer-facing companies and vendors began to present QR codes or URLs that gave some data and assurance of the provenance of a product- relating this capability to blockchain. At the time, IBM Research held blockchain development as a major research focus, and came to the table as an industry partner with CBTS. IBM's commercial product suite, Trade Lens, was being ramped up in earnest, in notable partnership with global giants such as Walmart and Maersk. But, change was a constant in the nascent CBTS COE and the inevitable time warp of US government goings-on brought about a number of changes in the direction of CBTS' blockchain work.

Chapter II of CBTS' blockchain endeavors

Time passed, and both the public and private sectors were wrestling with some of the realities of blockchain, and what it means. Questions arose, such as: network transaction throughput capacity, blockchain commit time, and the cost associated with blockchain use, relating to the type of blockchain in question and the energy required to resolve blocks therein. This was just the beginning of a debate over the merits of proof-of-work blockchain algorithms, with notable roots in the Bitcoin network. Whether considering a permissionless blockchain or a permissioned blockchain, network performance remained a potentially limiting factor. Simultaneously, CBTS was introduced to the Business Transformation and Innovation Division. (BTID) of the CBP Office of Trade. BTID made it clear that they were interested in vendor-agnostic blockchain research and solutions. Simultaneously, the focus on blockchain research at IBM Research was contracting, as AI functionalities and optimizations were taking center stag; a change that foreshadowed Maersk's recent divestiture from the TradeLens system due to limited global buy-in for a relatively high overhead system and consequent lack of ROI.

With IBM Research moving on, CBTS established partnership with Dr. Steve Liu and his team in the Texas A&M Department of Computer Science. Dr. Liu brought a diverse computer science, electrical engineering, and system engineering background to the table, giving him good perspective on the system design challenges associated with blockchains (also referred to as distributed ledger technologies) and their potential use in trade documentation/flow environments. The BTID office, with already established investments in the W3C standards for identity management, set the verified credential (VC) and decentralized identifier (DID) methods as requirements for the CBTS blockchain effort. And subsequently, BTID introduced tuna tracking as the trade-related question to be answered. This focus emerged in part from the COAC group in CBP, with interest in potential application of DID and VC to the complexities of the international

tuna trade. CBTS blockchain effort. And subsequently, BTID introduced tuna tracking as the trade-related question to be answered. This focus emerged in part from the COAC group in CBP, with interest in potential application of DID and VC to the complexities of the international tuna trade.

So, what about tuna?

It's distinctly international, with catches from remote locations in the world's oceans, and with frequent open water transfer of catches between vessels, and jurisdictional involvement from multiple national parties. Bluefin, yellowfin, bigeye, and skipjack tuna account for about 28% of the $150 billion, annual global seafood trade. Tuna fishing and processing supports a wide array of jobs across the world, and contributes to food security for over three billion people. The tuna fishing supply chain is a global enterprise, with fish harvest occurring in the far reaches of the open ocean, followed by processing and movement of this perishable commodity to market across international borders at maximum achievable speed. This complex supply chain, which involves an array of international fishing vessels, carriers, and waypoints combined with the environmentally sensitive nature of tuna harvest make this supply chain system a desirable target for enhancements in traceability and information availability.

Given the complexity and global reach of tuna fisheries and the tuna fishing industry, management and regulation of practices that influence the fisheries and environment is a very challenging task. Novel fish aggregating devices are increasingly common, with fish catches that are disproportionately comprised of juvenile tuna, resulting in fishery depletions that can exceed 96% of original fish densities. In the Eastern Tropical Pacific, where tuna naturally associate with dolphin, dolphin can be caught as by-catch in purse seine net fishing; a practice in which the dolphin pod may be the very target around which the purse seine nets are drawn. Another common practice, transshipment, in which fish are aggregated or moved between vessels on the high seas, makes tracking and reporting very difficult. Bad actors can obscure their activities and misrepresent information associated with the fish caught. It is estimated that over $100 million in tuna are transferred through some form of transshipment in the Central Pacific each year. These practices and figures illustrate the importance and complexities of the global tuna trade, and emphasize the necessity for both responsible regulation for import and enhanced traceability. And, during the course of this project, a number of Central and South American countries moved fisheries and illegal unreported, unregulated fishing into their top three national security concerns. While this may not apply exclusively to tuna, there is no denying the global importance of fisheries and their sustainability.

The CBTS Tuna Tracking System

The CBTS team established contact with a few key commercial tuna fish companies, in addition to NOAA, the government agency responsible for most fishery regulation. Working between CBP BTID and the commercial industry posed unique challenges in system design, and the project team scoped creation of a testbed system- the Tuna Tracking System (TTS). The intent here is not industrial or government implementation, but a flexible technology system in which new ideas for data management and trade traceability can be examined and tested- a permissioned blockchain based testbed to support the tuna supply chain. The aim here is offering a simulated data operational environment, so that the stakeholders can create realistic operational scenarios and test them on the testbed. Emerging concepts in trade and customs data availability really challenge existing paradigms of how the paper trail tracks in accordance with physical shipments. There is interest in accumulating verified, import-related pre-release data with increased frequency and specificity, for transmission into USG data systems. This kind of change to potential commitment of records into a USG record keeping system, prior to what has traditionally been a complete

documentation summary associated with an import, raises numerous paradigm-shifting challenges and the TTS team sees a technology testbed as the most appropriately scoped endeavor for this work. As one might imagine, the documentation chain associated with a catch of fish really does start on the fishing boat. For configuration of the documentation chain to be represented in what became the CBTS Tuna Tracking System, the team built a digital captain's statement (in Chinese and English), modeled after a review of numerous real-world examples. To capture an important US regulatory document associated with tuna import, the team incorporated a digital NOAA 370 form- the Fisheries Certificate of Origin.

These forms represent both important data and origin information from early and mid points in the tuna supply chain. In the TTS design, they are human facing system elements, interacted with through the web portal. The fundamental unit of operation/documentation throughout TTS is the trade event. We define a general concept of trade event (TE) to represent a reportable trade action, and its data needs to be logged to the tuna tracking system (TTS) for inspection. These TEs are essentially reportable business activities performed by nodes in the supply chain, defined at whatever appropriate level of granularity (temporal or role-based), that can be signed/associated with an immutable verified credential.

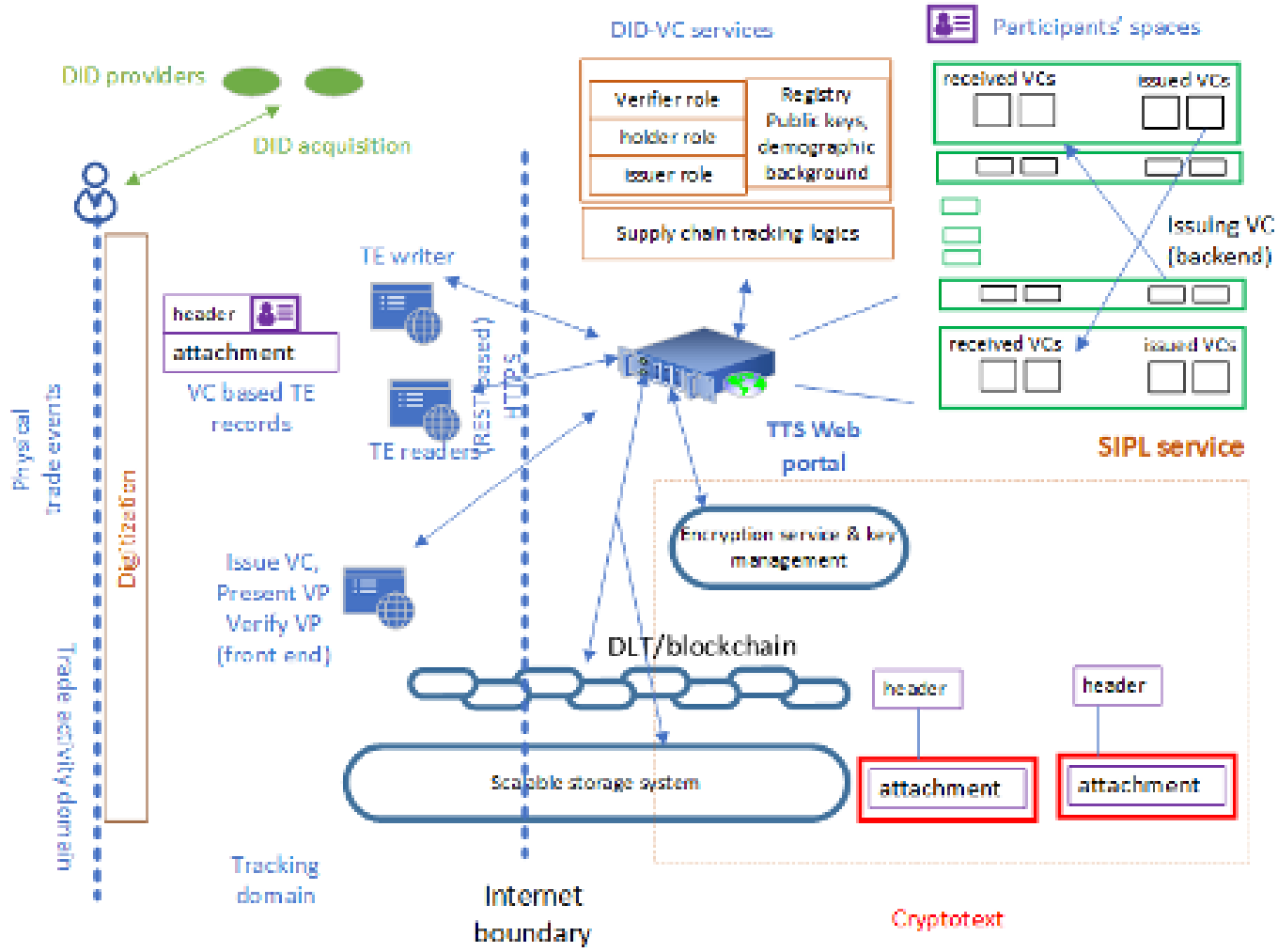
TTS- Summary of the Technical Bits

The key features of the TTS testbed are summarized as follows:

- A TE log is identified by a unique TE-header, which links to a TE-VC (a VC based form to summarize the reported TE), and an attachment (a detailed data file required for the reported TE.) Each TE being logged is assigned a decentralized identifier (DID) as its identifier, so that it can be uniquely identified.
  - The TE-VC is a W3C verifiable claim (VC) file, which is digitally signed by the author, so that its authorship can be verified.
  - When the required data for a TE is too large to be fit into a compacted VC file, it is modeled as a linked attachment to the TE.
- A Scalable, Immutable and Privacy protected Logging (SIPL) computing architecture to meet the logging requirements of the TTS system.
  - Immutable logging: A permissioned blockchain supports immutable logging of headers of TE log entries.
  - Scalable storage: A highly scalable storage architecture Interplanetary File System (IPFS) is used to support storage of large data files.
  - Privacy protection: Private data of a TE log is encrypted so that only authorized principals can access their plaintext contents.
- Users use a web browser as its user interface (UI) to access the TTS service.
- A web portal architecture uses the SIPL, plus other necessary data management tools and custom codes, as its backend computing infrastructure to provide TTS services.

- Form digitization. Two common tuna forms, NOAA Form 370 and a bilingual captain's statement were implemented as web pages. They are used as a part of testing inputs to demonstrate and evaluate the key operations on selective supply chain nodes.

The overall system architecture of the TTS testbed is shown below. At center of the TTS system is the TTS web portal that interacts with user web traffic, and coordinate computing actions among backend subsystems to perform TTS services. Running on top of a Linux operating system, the Flask based web portal is integrated with a MySQL relational database to support user management functions. A number of reengineered and in-house built custom codes run on the web portal to serve TTS functions. The DID-VC services responsible for processing (parsing, signing) of VC based data. The SIPL service is implemented based on the Indy blockchain,



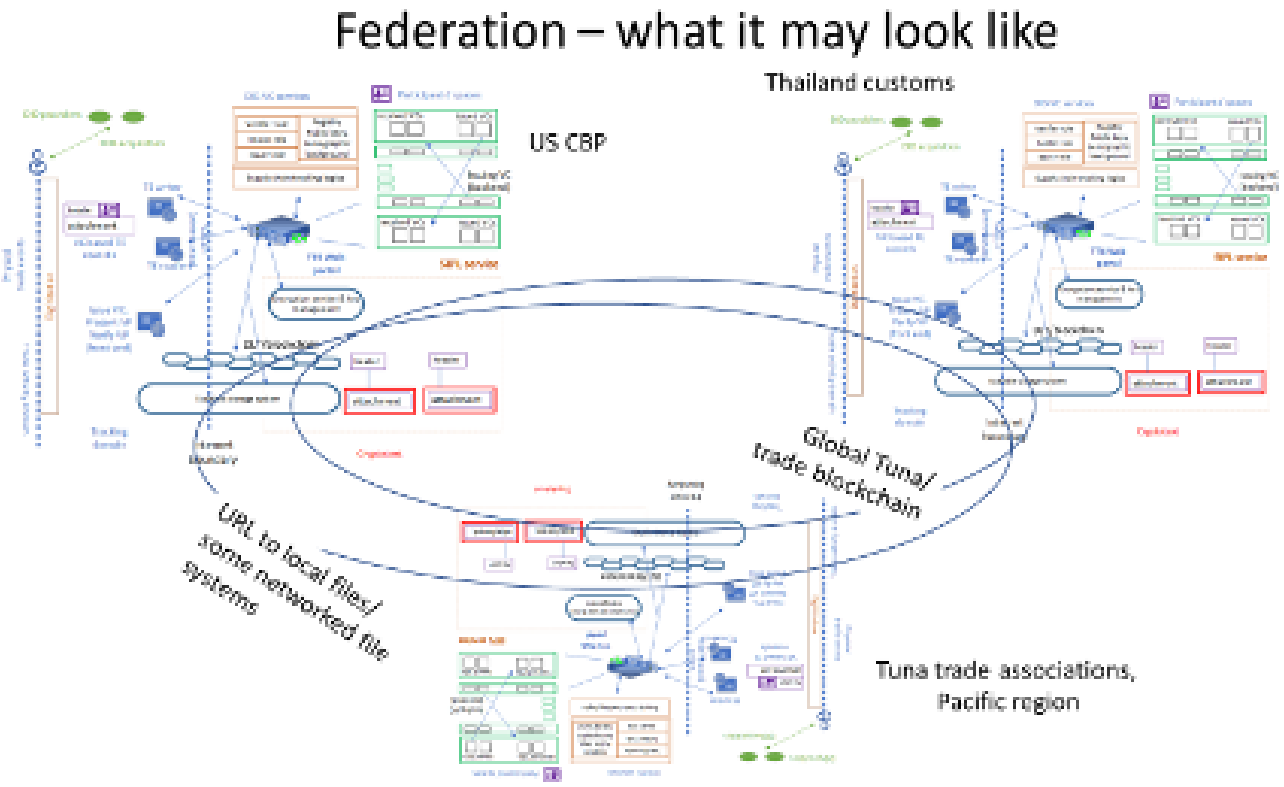
The TTS testbed architecture

the Encrypted Data Vault (EDV), and IPFS. A number of networking codes are implemented for the web portal to interact with the web browsers, and subsystems in the SIPL service model. The web browser is used as the user interface, so that users can access the TTS for logging and inquiry of logged TE records.

A tuna supply chain, like many other large supply chains, spans around the globe. Commonly a trade principal needs to report data locally, yet such data is still needed by the U.S. authority for U.S. bound products. In light of the complex geopolitical and policy differences of different regions, it may not be practical, nor financially viable, to model the architecture TTS as a single point of data operations. At least for now. Rather, we envision a "localized frontend data service, shared/linked backend log access" architecture for TTS. The basic idea is to treat the overall TTS as a network of internet worked regional hubs. Each hub operates its own "web portal" for its regional trade operators, who report data through those "localized frontend" to the local hub

The local hub collects the data for its regional purposes. And in the process, some data adaptor type service logs the data onto a SIPL based logging network so that the locally reported data is made available to authorized parties. We note that SIPL service model is inherently networking capable. To support global access of logged data, a regional tuna trade hub can clone the TTS web portal architecture for local data processing.

A conceptual illustration of the internet worked TTS hubs is given on the next page, where the image of the third hub located at center bottom is flipped upside down for better graphic representation.



The internetworked regional TTS hubs.

What did we end up with?

A very functional testbed, that necessarily hybridizes distributed ledger technology with more traditional encrypted file storage technology and a clever system of data logging and associated key management for privacy protection and parsing of public and private data access. This design invokes the useful aspects of blockchain while optimizing system performance and ability to handle sizable data payloads for transmission. And, very important, the VCs generated in unison with trade events, nest, one inside the other, as records progress through the supply chain-yielding readily accessible and verified forward and backward traceability from each trade event or node in the supply chain. Pretty cool! And, all of this is novel in this space. It gives both the government and the industry kind of a road map and working testbed for testing and implementation of these paradigm-shifting ideas for trade documentation, verification, and flow.