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The Digital Title Network

TRANSFORMING VEHICLE OWNERSHIP IN THE UNITED STATES

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I. Executive Summary

It's astonishing that for the vast majority of Americans, the only proof that they own the car in their driveway remains a relic of the past — a piece of paper called the vehicle title.

Despite paper-based processes being phased out of most other corners of our lives, both the automotive industry and consumers remain burdened by the antiquated, paper-based infrastructure of vehicle ownership. While paper has been a medium of record-keeping for centuries, its drawbacks are evident in the context of modern vehicle ownership. Inefficient, susceptible to loss or theft, and vulnerable to fraud, the traditional paper title hampers the efficiency of the entire car ownership experience.

The frustrations of dealing with paper titles are all too familiar to American consumers, with many of us harboring tales of lengthy queues at the DMV, bureaucratic hurdles, and the anxiety of potentially misplacing or losing a crucial document. Instances of unwittingly purchasing fraudulent titles contribute to the challenges faced by individuals who, upon reaching the DMV window, discover the devastating financial consequences of a deceptive transaction.

The issues and challenges for the automotive industry are also significant. More than half of all vehicle transactions that occur each year involve an automotive dealership and/or a lender. These entities face the unenviable task of managing this difficult paper process operationally, often at staggering scale. Dealerships lose untold millions of dollars a year in carrying costs as vehicles idle on the lot, waiting on the delivery of a paper title before they can be legally sold. Lenders incur huge operational costs and risks in managing the creation and fulfillment of vehicle liens. Customers confused about this process flood these businesses, as well as their local DMV branch, with endless phone calls and inquiries. We all sense it: something has to change; the paper title must go. But how to do it? The titling ecosystem is incredibly complex, with participants and stakeholders across the American economy.

In this paper (no pun intended), we present the solution to this problem: A nationally interoperable, digitally enabled, and technologically flexible end-to-end digital titling system designed from first principles to serve the disparate needs of the US's vast titling ecosystem. The solution enables instantaneous and verifiable transfer of title, while creating a fully interoperable and highly flexible digital title asset. The innovation of a digital asset representing the vehicle title gives vehicle owners a bearer instrument they can hold in their own custody – for instance in their Google or Apple wallet – conferring the same level of ownership and autonomy to them that the paper title does today, without any of the security flaws. This digital title asset further unlocks a new and exciting world of applications for the industry and for individual motorists that promise to drive value in new and exciting ways well into the future.

The solution is characterized by a highly flexible peer-to-peer networking approach. Titling transactions can be complex, with many different types (B2B, C2C, B2C, interstate, etc.) and stakeholders (one or multiple lienholders, buyers, sellers, jurisdictions, etc.). However, regardless of the complexity, the system ensures the highest degree of data fidelity and speed by receiving timely digital attestations on every action directly from the source. Later in the paper, we will show how the system can structurally guarantee privacy and data ownership while maximizing for speed, efficiency, interoperability, and – very importantly – the ongoing enablement of jurisdictional preference and rulemaking autonomy.

A fully digital and interoperable titling solution represents a fundamental leap for national titling capabilities. Not only does it unlock massive transparency for the industry, simultaneously making most of today's fraud schemes obsolete, but it also paves the way for a faster, easier and more efficient future with beneficial value-added applications. Our hope is that we seize this opportunity in history to build a functional, flexible, and utilitarian titling ecosystem for all current and future Americans.

II. Introduction

The concept of electronic titling, or e-titling, in the US is far from new. The American Association of Motor Vehicle Administrators (AAMVA) first recognized the benefits of e-titling in the early 1990s to increase efficiency, reduce costs, and mitigate fraud. By the mid-90s and 2000s, initial solutions – the Electronic Lien and Title (ELT) systems – began to emerge to handle electronic communication of liens between lenders and the DMV. Over the 2010s, the scope of capabilities continued to increase, for instance with Electronic Title and Registration (ETR) systems that in some states interact with dealers' dealer management systems (DMS) software directly.

Then, in 2019, the landmark ruling by the National Highway Transportation Safety Administration (NHTSA) on e-odometer disclosures established the rules for fully compliant electronic signatures[1]. This represented a paradigm shift: up to this point e-titling automotive transactions still had to involve the electronic submission of paper documents to capture the requisite wet signature, but now the door was open for more complete systems that could eliminate paper processes entirely. AAMVA working groups moved quickly to release two white papers in 2021 and 2022, each outlining the ways states could approach the transformational journey towards e-titling. At the start of 2023, the body took further decisive action by commissioning a 2-year comprehensive study of the entire titling landscape across the automotive sector, a clear signal that jurisdictions across the country are serious about moving forward. At time of writing several states, including Texas, Arizona, California, Virginia, Georgia, West Virginia, and others have taken serious strides towards setting up their own solutions to enable some form of e-titling for their constituents. However, today's e-titling solutions don't go far enough. While they do lessen the overall dependency on paper, they tend to be piecemeal in scope (covering a very limited set of transactions) and incremental in impact. In almost every case the output of the process is still a paper title in the hands of the new vehicle owner.

As legislators begin writing mandates and states explore possibilities, we – citizens, states, and the automotive industry - find ourselves at a rare and significant moment in the industry. For the first time in decades, we have an opportunity to reimagine the way vehicle administration and transfer of ownership is conducted and experienced. **We should use this opportunity not just to imitate the current process in an electronic format, but to create a totally digital experience for vehicle administration that brings forth major enhancements with the full benefit of modern technology.** In doing so, we can make vehicle administration safer, more efficient, more dynamic, and less expensive for everyone.

[1] https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-580

In that spirit, we put forth the central questions: What should the ideal digital titling system look like? What new or existing services and capabilities should it comprise? And, considering this is a system expected to have great longevity, how should it be architected, both technically and fundamentally, to fulfill its mission long into the future?

In the next section, and over the course of the paper, we set forth to answer these questions. Taking a first principles-based approach, we begin by defining key "pillars" of an ideal digital titling solution; enhanced safety, digital processes, network coordination, interstate capability, and digital title creation. Then, to complete the picture of requirements across the tiling ecosystem's myriad stakeholders, we examine the unique and disparate needs of each of the key titling business network participants. Finally, we introduce a solution that maximizes for each of these requirements, while adhering to core technological tenets of functionality, interoperability, scalability, flexibility, and futureproofing. We dive into the unique benefits and key architectural elements of the approach, and end by offering our proposal for how the business network and AAMVA community can think about the complicated path towards modern, comprehensive, and nationally interoperable digital titling.

III. The Functional Pillars of a Fully Digital Titling System

The first-principles approach to problem-solving is a method defined by breaking down complex ideas or problems into their most basic and fundamental components. By identifying the core elements of a situation or problem and reconstructing the solution from the ground up, first-principles thinking encourages innovative solutions that are sustainably rooted in fundamental realities.

In order to apply this approach to the construction of an ideal modern digital titling solution, we must first define the critical components and business requirements. These can be broken down into five general areas: i) Consumer/Buyer protections, ii) digital submission of documents, iii) coordination of the parties involved, iv) interstate transfer capabilities, and v) digital title creation.

i) Consumer/Buyer Protections

Any digital titling system must prioritize – amongst other things - safety. Stakeholders must trust the system to safeguard their data, protect their privacy, and maintain the fidelity of information represented and requested. Users of all sorts, including institutions and individuals, must trust that their private and confidential data (including PII) is safeguarded, their application information, data, and documents are submitted and stored securely, and – critically – that the counterparty(s) on the other end of the transaction are who they say they are.

To engender this trust, a modern digital titling system must be able to dynamically verify the identity of parties that give their digital attestation (a.k.a. e-signature) on important documents, such as the Bill of Sale, the Odometer Disclosure, lien releases, Power of Attorney forms and more.

NHTSA's landmark 2019 rule elucidated the specific National Institute of Standards and Technology (NIST)-promulgated requirements for accepting digital signatures. The rule specifies that a compliant digital signature requires the user to prove their identity at the time of making their signature via the stringent remote identity proofing standard known as Identity Assurance Level 2 or IAL2. IAL2 stipulates a user, whoever they are, must present at least one piece of "strong" or "superior" evidence such as a Driver's license, State ID, or Passport document, along with validating their identity via a timely

biometric authentication[2]. This authentication level standard was specifically prescribed for use in jurisdiction e-titling systems by AAMVA in their first e-titling whitepaper from November 2021 "Electronic Titling Framework"[3]. The goal of requiring such a strong verification standard was consumer protection. Adhering to this standard for all significant digital signatures would give users of digital titling the confidence they need to transact without necessarily meeting their counterparties in-person or having to be physically in front of a DMV clerk. It also greatly ameliorates the risk of a lost password or ID card resulting in an unwanted transfer: a malicious actor that gains access to a user's account on the digital titling system would still not be able to provide a valid digital signature and thus would not be able to affect a fraudulent transfer of title on the system.

Another major tenet of consumer protection is fraud prevention. While robust identity proofing is a great tool to reduce and deter fraud, many other avenues for fraud exist today that don't involve the parties' identities. Vehicles are stolen, fake titles are created using sophisticated image management software, VINs are fabricated, and vehicle history is counterfeited or spoofed.

This would not be the case in a nation where digital titling is the prevalent way to transfer vehicle ownership. DMVs today capture data about the up-to-date status of the title, as well as the current rightful owner. NMVTIS, moreover, captures data on stolen or branded vehicles. Digital titling systems could easily integrate with these existing systems of record to bring forward important safety checks, such as who is the rightful owner of the vehicle and whether the vehicle has been reported stolen. For example, digital titling interfaces could be designed to only show vehicles the user has title to. This would mean a seller can only initiate ownership transfers for vehicles where the state recognizes them as the owner. In such a system, VIN fabrication, spoofing, and/or title counterfeiting would no longer be an effective way to dupe buyers.

In a more forward-looking vein, as digital titling becomes more and more prevalent in the US, a complete picture of vehicle history and digital provenance could begin to emerge. Stakeholders would enjoy unprecedented transparency, increasing confidence in the used car market and obviating the need for expensive third-party data providers such as Carfax. The cost to provide or acquire trust in the used car market could be greatly reduced, and the ancillary benefits to such a shift could be enormous for used car owners and dealerships across the US.

The final aspect of consumer protection worth mentioning is the ability for a solution to detect a fraudulent paper title. Even as digital titling becomes more prevalent, there will be many cases (especially in inter-state title transfers from a state that still uses paper) where a paper title will be the launch point of a title transfer. In these cases, there must be software (and models) in place that allows the detection of a fake title. Deep machine learning models combined with natural language processing (NLP) and optical character recognition (OCR) tools should be able to detect even the most sophisticated forgery, radically minimizing or eliminating the possibility of title forgeries.

Modern digital titling systems need to take all of these potential consumer protection elements into careful consideration. Some can be seen as requirements (for instance, IAL2 verification) while others (exact methods of fraud prevention) can be construed as opportunities. Ultimately, by making enhanced

[22] https://pages.nist.gov/800-63-3-Implementation-Resources/63A/ial2remote/
[3] https://www.aamva.org/getmedia/855615a8-b71d-4641-a422-f7706716faf2/Electronic-Titling-Framework_final.pdf

consumer/buyer protections a core design principle, modern digital titling system implementations have the potential to bring unprecedented protections and safety checks into the ecosystem.

ii) Digital Submission

For most, one eagerly anticipated benefit of digital titling is skipping the trip to the physical DMV. All stakeholders to the titling transaction, whether they be consumers, dealerships, or lienholders, should be able to electronically communicate all salient information about the titling transaction to their DMV, without the use of paper. This includes documents or information that comprise an application for title and/or registration, documents or information that precipitate the addition or release of title liens, and documents or information that contain critical updates to a vehicle's titling status (for instance, title brands).

Clearly, the capability to accept virtual/electronic documents and information is a necessity to effectuate true digital titling. The results of a comprehensive digital submission capability are a massive increase in efficiency (for all parties, but especially dealers and consumers), and a reduction in expensive human activities required by the management of paper.

Of course, electronic communication for titling is far from a new idea. Electronic lien and title (ELT) communication systems have been at the forefront of e-titling from as early as the 90s, through today. At time of writing, 31 state jurisdictions have or support ELT systems as a method of communication between vehicle lenders and the DMV. The goal of these systems is to increase efficiency in the lien management and release process. That said, ELT systems represent an incomplete electronic communication solution for a few reasons. First and foremost, because it still ultimately depends upon paper. Secondly, ELT only shares data between lenders and the DMV, no other parties are immediately made aware of the lien. Third, lien information comprises just a small set of the information that needs to be exchanged, managed, and updated during a titling transaction.

On the other hand, the ideal modern digital titling system would need to support the electronic interchange of information and documents between *all* key parties to a titling transaction. These parties could include individuals, dealerships, financial lienholders, non-financial lienholders (e.g., mechanics shops), insurance companies, OEMs, salvage yards, law enforcement, and more. For such a vast network, uni-directional or bi-directional data flows, such as ELT systems, are insufficient. Digital titling systems must strive towards true omni-channel, *multi-directional* data flows to all titling stakeholders, and digital submission capabilities that can service the requirements of the diverse automotive business network.

As digital submission capabilities are implemented and grow, they should be able to provide transparent sequencing to different critical workflows, especially titling. Participants in a titling transaction often need to know the correct sequence of events of a vehicle's prior lifecycle as they interact through the transaction. Before signing a bill of sale, the buyer wants to be sure the car hasn't been involved in a transaction, or a theft, elsewhere. Before approving a loan, a lender wants to know that the previous one has been released correctly, and no other has since been filed. Before approving a registration, a DMV wants to verify that the motorist has insured the vehicle and received an inspection for it. Whoever you are, the ability to check the correct sequence of events in a vehicle's lifecycle, or during a titling transaction, has tremendous value.

Digital submission capabilities should be built to enable complete and transparent sequencing for these events. For instance, by accepting a wide breadth of interactions from the different key stakeholders and

timestamping them sequentially before storing them. Of course, such comprehensive digital submission capabilities will take time to develop. Digital submission involves change management and training at the DMV and for the many titling stakeholders. In certain states, statutory changes may still be needed to enable electronic submission and fully digital attestations.

That said, the investment in this area could well be worth it. Getting consumers and stakeholders comfortable with fully digital submission could pave the way for government and the private sector alike to offer more and more vehicle services online. The benefits are significant: reduction in human error, relief of tedious clerical work for staffers, and increased convenience and reduced costs for everyone. To best realize these benefits, modern digital titling systems should make comprehensive electronic submission capabilities a core design principle.

iii) Network Coordination

Transferring vehicle ownership usually involves a "network" of multiple interested parties: A buyer and seller (either individuals or institutions), a financer (lienholder), and the state regulator (DMVs). Some transactions can involve even more: multiple buyers or sellers, multiple lienholders, insurance companies, and even law enforcement. One of the central problems of effective titling lies in *coordinating* all these disparate parties together. In fact, this is exactly what the entire legacy paper titling process is designed to do today. The bill of sale and odometer disclosure coordinates the buyer and seller, the lien payoff authorization or ELT communication coordinates the lienholder and the state, the entire deal package for the state and the new owner. If something goes amiss, it's almost certainly because one or more of the parties is not properly coordinated with another. A missing or incorrect lien is a coordination failure of the lender, a faulty bill of sale is a coordination failure with the parties conducting the sale, an incorrect brand is a coordination failure of the insurance company or salvage yard. Similarly, when a new owner comes into the DMV with their title application but wasn't aware they needed a proof of residency document, or that they needed 50 extra dollars in their money order for the registration fee, that is a coordination problem between themselves and the state DMV.

Even incidents that involve malfeasance – such as title jumping[4], title washing[5], and counterfeiting – can be boiled down to problems in coordination. Counterfeiting, for instance, is a coordination problem between the buyer of the counterfeit title and the state. The state DMV knows the title is fraudulent, but the buyer is duped into thinking otherwise because they are not properly coordinated with, i.e. aware of, that important piece of information held in the DMV system of record. They only find out – much to their dismay – when they make it to the title clerk's desk, with the rest of their title application in hand.

Most coordination problems are the result of data silos and the fact that the title is a piece of paper. In the counterfeiting example above, the source of truth for the validity of a given title document number is siloed at the DMV, and the key stakeholder to the transaction – the unfortunate buyer – does not find out until it's too late. In the example of a missing lien or missing brand, the critical piece of data is siloed

[4] "Title Jumping" occurs when a buyer of a vehicle turns around and sells it to another buyer, without getting the vehicle titled in their name first.

[5] "Title Washing" occurs when a car owner transfers their vehicle title from a state with certain reporting requirements to another state with different requirements, usually in order to remove unwanted brands (such as salvage brands) that would affect the vehicles resale value.

either with the lienholder or the insurance company, respectively. It is not available to the right party at the right time.

Data silos further lead to opaque sequencing, which is another common form of coordination failure. As was illustrated in the prior section – titling stakeholders and participants often need to verify the prior events in a vehicle's lifecycle, such as its various phase of life (MSO/MCO through to salvage and brands/flags) and phase of ownership (different owners/lienholders) changes. When data is siloed, the correct sequence of events can be unclear when certain pieces of data may be siloed from the complete picture.

In order to solve these fundamental issues, a modern digital titling system should make the enablement and facilitation of strong network coordination a core objective and central design principle. All participants to a titling transaction should be able to see the information important to them, in correct sequence and in real-time. The only practical way to achieve this is by creating a digitally integrated, end-to-end solution. It is certainly a daunting task, but by focusing on removing data siloes and creating a single source of truth, one would introduce transparent sequencing for the critical information and processes stakeholders interact with at various stages of titling, facilitating unprecedented levels of transparency and network coordination. Structural approaches for this concept will be discussed further in Section V.ii.

iv) Interstate Transfer

Interstate transfers today account for as much as 15% of all motor vehicle transactions. Motorists move across state lines, and digital titles must also. However, planning to interoperate with 50 different state jurisdictions is a daunting prospect. In their 2021 whitepaper, AAMVA highlighted the need for states to maintain autonomy with how they implement e-titling, but also recommended the adoption of "minimum standards" to facilitate future interoperability. Indeed, certain minimum standards would be highly beneficial for the state jurisdictions and the industry to coordinate around as they begin (or continue) to build digital titling capabilities. Namely:

- Standards for access management and interstate identity resolution
- Standards to securely transmit required information between states

These minimum standards would help to ensure that future national interoperability efforts would not involve having to "rip and replace" entrenched e-titling systems, but rather allow them to integrate together with minimal effort and minimal breaking changes.

That said, until such standards are promulgated by the AAMVA community, modern digital titling systems should adopt the core design principle of broad tech-stack agnosticism and data model flexibility as much as possible. One way this could practically work, before a national standard is promulgated, is by creating a super-set of the data required by all 51 DMVs for both titling and registration. The system could use this superset to add data elements to a digital title as needed when titles move between states with different data field requirements on the title. This way the system could ensure no title data is ever lost (or washed), while adhering to state-specific title and data requirements.

v) Digital Title Creation

It probably seems obvious that the output of a digital titling system should be an digital title, but the characteristics of that output deserve careful consideration. Specifically, it is important to differentiate

between the concept of a merely “electronic” title, and what we define as a “digital” title. To understand this differentiation, we should start by taking a look at the properties of the long-lived paper title.

The paper title has been around since the early 1900s (the first one was issued in New York in 1901). For all its flaws, this paper document does one thing well that is difficult to replicate digitally, but important to maintain: It confers ultimate custody and responsibility over the ownership document to the owner themselves, *not* to the state government or some other institution. The merit of custodial ownership should not be overlooked. First and foremost, it allows the bearer to transfer ownership instantly. Furthermore, it gives consumers confidence in their ability to resolve disputes immediately and engender trust with the governing bodies. It gives citizens the autonomy they deserve in their ownership of a very significant asset to them. Although your paper title can be lost or stolen, while in your possession it cannot be disputed, obfuscated, or rendered inaccessible. It is the ultimate and final proof that the ownership to the vehicle lies with you. Tomorrow’s title document should maintain these core essential properties.

A “digital” title, then, is a digital asset that confers the same autonomy to an owner that a paper title does today, just radically better. It is independent of any singular database, cloud service, or application. There is no counterparty risk involved, no external access requirements, and no possibility for ownership disputes. In short, a digital title can be held independently on your person (for instance, on your phone), and can be directly accessed by you at any time.

On the other hand, an “electronic” title is an electronic record that merely exists only in the central database of some institution. A record on a database can only be accessed at the behest of the party running that database, and that same party must be trusted to maintain security, hosting, and access controls. It requires trust on behalf of the owner but confers none back to them. More importantly, it creates more barriers to actually use the asset productively on one’s own, a concept which we will explore a lot more later. In short, an electronic title is one that cannot be held independently on your person and can only be accessed at the behest of a third-party.

Imagine a scenario where the ownership of a vehicle is in dispute between two neighbors. Today, one of the owners will pull out their title – and the dispute is over. In a world of electronic titles… rather than pull out the title, the owner would have to persuade the other person to follow them to a computer where they access and log into a DMV website and see some rendition of the electronic title there. On the other hand, in a world of *digital* titles, the owner can pull out their phone and show the digital title in their possession, just as they would a paper title. The other person could scan this digital title with their phone and confirm it was signed and issued by the local DMV.

To summarize, an electronic title loses the autonomous properties of today’s paper title, while a digital title maintains them. We believe a modern digital titling system should set forth as a central design tenet the creation of a digital title, not just an electronic one, lest we ask titling stakeholders to give up their sovereign right to ownership, custody, and responsibility over this important ownership document.

It is also important to mention that a digital title – which exists natively on the blockchain as a digital asset - can be used in futuristic applications that unlock new services and value for motorists and the auto industry as a whole (we give some examples later in Section VI.iv). To prevent any misuse, digital titles should link back inextricably with the authoritative record at the state DMV, which continues to safeguard any PII or approve important transactions. Further, in order to maximize their utility and avoid

technology lock-in, digital titles should be as self-sufficient and system agnostic as possible. Such design principles will naturally make them interoperable, modular, and utilitarian; important forward-looking properties that will be discussed further in Section VI.iii.

IV. The Digital Titling Business Network

One of the challenges to construct a robust modern digital titling system is just how vast the stakeholder landscape is in the automotive industry. In this section, we will examine the key network participants to and stakeholders to digital titling one at a time. We will stay focused on the most critical participants: Dealerships, Lenders, DMVs, and Consumers, and only briefly discuss the other, ancillary participants.

i) Dealerships

Car dealerships are a business network participant with which we are all familiar. Dealerships range in size from a small, mom and pop six-car lot to a massive commercial franchise with six lots per store. Dealers also come in many different types, serving different functions across the market. Some are franchised, many more are independent. Some are retail and wholesale; others are exclusively wholesale. But regardless of their position, they must interact with the state DMV to title their vehicles and (as is often the case) assist their customers in titling as well. Taken together, these various Dealerships process the most vehicle transactions on a day-to-day basis than anyone except the state DMV itself.

Retail dealers focus on individual end-customers, we'll expand more on them at the end since they are the most complex.

Wholesale dealers act as the middlemen, focusing on logistics and the seamless transfer of clear titles in B2B transactions.

Auction houses operate a more fast-paced business, requiring rapid title processing for a diverse buyer pool and compliance with cross-jurisdictional title transfers.

Fleet managers oversee large collections of vehicles and have a need for comprehensive titling systems that can handle the complexities of fleet renewals and interstate transfers.

Regardless of where they are in the market, dealers compete to streamline the end-to-end purchase experience for their customers. In the hands of a dealer, a title is cash, and any delay in receiving title directly impacts their ability to turn inventory, which directly impacts their business. For instance, many large dealers will floor-plan finance their inventory, and thus will be responsible for monthly interest payments on every car that sits on their lot. This means that any time spent waiting for title before the car can be sold directly translates to lost money for the dealer. In this case when we say "sold", we mean transfer of ownership. Thus, when it comes to titling, dealers fundamentally want speed, clarity, and instant ownership transfer which brings confidence in the process for everyone. They wish for a completely frictionless process where titles are transferred as soon as the sale is made.

The titling process for retail dealers deserves special consideration. Today, most sizable retail dealers have specialized software – known as Dealer Management Systems (DMS) – that can sometimes

facilitate parts of the title and registration workflow for them. The F&I manager keys in the deal information, and the DMS spits out the required titling documents for the dealer to print and collect customers' wet signatures on. Depending on the software and the state of play in the jurisdiction, a dealer's DMS may sometimes also communicate with the lienholder, or even with an insurance provider or other parts of the business network.

The variety of DMS systems in use, and the fact that other dealers still may not use a DMS system at all, means that retail dealers in particular need integrated titling solutions to avoid changes in workflow. Many states that have implemented electronic dealer titling systems, such as Texas (WebDealer) and Georgia (E-Drives), have come to the same conclusion. In these states and others, dealers' DMS systems communicate directly to the DMV's e-titling system, although the final instantiation of the title still involves paper. Dealers have told these states that they want speed, clarity, and ease of use, while minimizing any costly workflow changes.

ii) Lenders

Auto finance lenders provide a critical service to make vehicle ownership viable for millions of Americans and give businesses and individuals alike access to financial services such as vehicle purchase loans, car equity loans, refinance, floorplan lending and more. These lenders are a diverse stakeholder group that includes various types of financial institutions, from rural branches to national giants to name-brand captives:

Credit unions and small local lenders tend to offer a more intimate transaction process, directly involving themselves in titling and lien placement to ensure that ownership transfers are smooth and comply with local regulations.

Commercial Lenders operate on a much larger scale, employing sophisticated systems to manage and record liens across a vast network, often involving third-party services that interact with state ELTs.

Retail Lenders provide important financing serving to consumers. They must ensure their security interest is recorded on the owner's title, and appropriately released once the loan is paid off.

Floorplan lenders provide financing to dealerships for their vehicle inventory. They must be involved in the initial titling process, ensuring their security interest is properly recorded at the time of the vehicle's acquisition and subsequently released or transferred upon the sale to the consumer.

The existing titling process for lenders is arduous, expensive, and inefficient. Today's paper-based process creates significant challenges in efficiently creating, managing, and enforcing lenders' security interests in vehicles. The key pain points include prolonged processing times due to manual procedures, risk of errors from manual data entry, and the substantial costs and logistical difficulties associated with the storage and organization of physical documents. Additionally, the paper-based system poses notable security risks, ranging from physical damage to documents to theft and loss, alongside compliance challenges arising from the varied and complex state-specific regulations. The limited accessibility of physical documents also greatly hampers operational efficiency for larger lenders, particularly in terms of integrating with their existing business systems, responding to audits, and/or addressing customer inquiries. The seriousness of these challenges is what led ELT to be an early-adopted "e-titling" solution.

However, even in states with ELT systems, the lien creation process is still often paper-based, requiring lenders to mail in paperwork to the DMV. Moreover, ELT-state lenders no longer hold a bearer

instrument. They don't have the title themselves and thus are not able to provide information from it to their inquiring customers, instead directing them to call into the local DMV. This hampers lenders' ability to satisfy their customers' needs and increases call volumes at the DMV.

The common thread for lenders of all types is the need for assurance that their financial stake is protected by the states and within the courts, coupled with speed and efficiency in creating and managing these lien interests. Ultimately, lenders are in the business of balancing risk - reward, and challenges in effective titling and lien perfection directly impact the risk side of the equation. Therefore, the level of assurance a lender can obtain – in relation to the security of their interest in the vehicle – is directly related to the level of service (i.e., loan terms and borrowing rates) they can provide to their customers and the titling business network as a whole. Furthermore, lenders are in the business of maximizing interest returns and finding new ways to lend. A digital title would open a plethora of new opportunities to them.

iii) DMVs

DMVs are the ultimate arbiter of vehicle ownership and security interest. They have the unenviable role of being the rule-maker, enforcer, and operator of this process all at the same time. As an agency of the State, DMVs have a mission to provide trust, clarity, and accessibility of titling and registration services to their constituents: the American populace and all of the institutional stakeholders.

As they work to fulfill their mission, DMVs must balance cutting-edge innovative services that introduce new value with feasibility and accessibility to the larger populace. Their mandate to serve means they cannot cater solely to a single demographic or stakeholder need; they must consider the entire network. DMVs can neither move too fast nor too slow in implementing new services and solutions, especially in regard to digital titling.

DMVs must also consider the difficult questions of scope, cost, usability, feasibility (e.g. with existing digital infrastructure), and the current state of play in the jurisdiction. For instance, some state DMVs already have robust ELT networks, or have taken the time to stand up home-grown Electronic Vehicle Registration (EVR) or Electronic Title and Registration (ETR) systems. Still other states have legislative hurdles to consider, such as setting the proper protocol for accepting digital attestations on official documents within the title application. AAMVA's 2022 whitepaper provides a great framework for managing expected jurisdictional hurdles as the national move towards digital titling gains steam[6].

Another concept that DMVs must contend with when building their new digital titling systems is futureproofing. No DMV wants to be in the situation of finally completing a large, multi-year project only to discover new requirements have materialized in the interim. Moreover, DMVs want to minimize the costs of upgrades and replacements in the future, as these systems are expected to have multi-decade lifespans. DMVs must face the balancing act of providing the digital titling services demanded by their stakeholders while controlling for all of these key considerations.

iv) Consumers

Individual consumers are the end-users, the most numerous and diverse of all the stakeholders to digital titling. It is likely that everyone reading this paper, whether or not they fall into one of the other

[6] https://www.aamva.org/getmedia/9abc4cbf-e932-41a0-9ee9-5bc245337657/Jurisdiction-Considerations-for-Electronic-Titling-Whitepaper-Final.pdf

participants described, identifies with this stakeholder group. According to a 2022 Census Bureau survey, as much as 91.7% of US households owned at least one vehicle in 2021[7].

When it comes to titling, consumer's demands are simple and relatable: they want speed, instant ownership, clarity, safety and efficiency. Most consumers would skip the trip to the DMV if they had a chance. Most important is **ownership** – with ownership comes piece of mind. In a digital titling world, consumers ought to have the option and capability to receive and hold their title digitally on their device that is with them at all times: their smartphone. We need not rehash all the benefits of a digital title (covered in section III.v) here, but we again emphasize the focus on autonomy, utility, and sovereignty to best empower the title owner.

The design principle of Consumer Protection should lead us to look for other ways the shift to digital titling can benefit and safeguard motorists. The used car market in the US today is probably best described by the old adage: "Buyer Beware." Buyers today must contend with a largely opaque process around assessing the vehicle's history, satisfying any existing liens, and ensuring the title document is legitimate and up to date. As any DMV investigator would tell you, the situation – particularly on online used-car marketplaces – is rife for abuse from fraudsters, who peddle stolen vehicles with counterfeited or washed titles. Unfortunate consumers often have no idea they've been duped until they show up at the DMV clerk's counter with their paperwork in hand. However, modern digital titling systems can use some of the techniques described in previous sections – IAL2-compliant digital signatures, integration to existing authoritative systems of record, and title-scanning technology – to bring forward fraud checks and imbue greater trust and transparency into tomorrow's titling process.

In a digitally enabled future, an exciting prospect for consumers is the emergence of new applications and services that can interact directly with their digital ownership record. It is already possible to manage and monetize ownership of other digital assets from the comfort of your home, why not vehicle titles? Beyond the inherent ability of proving ownership and settling disputes, motorists in the future could use their digital title to unlock data, receive financing, share (fractionalize) ownership, transfer ownership instantly and securely, and more. It is likely that more and more digitally-savvy motorists will demand these types of services over time, and it is therefore important to create a digital titling platform that maximizes for future digital capabilities that can add value to the motoring public – all of us!

v) Other Participants

In addition to the key participant types described above, there are many other stakeholders to vehicle titling in the US. These include, but are not limited to, insurance companies, salvage yards, vehicle manufacturers, mechanic shops, taxing authorities, and law enforcement. Each of these ancillary participants also sometimes act as an important primary data source for certain data elements that are salient to a vehicle's lifecycle:

- Insurance companies: Vehicle brands and car insurance verification (for registrations)
- Salvage Yards: Salvage brands and end-of-life management
- Manufacturers/OEMs: MCO/MSO origination and start-of-life management
- Mechanics shops: Mechanics liens and brand verification
- Taxing Authorities: Taxing liens and ownership management

[7] https://www.forbes.com/advisor/car-insurance/car-ownership-statistics/

- Law Enforcement: Stolen vehicle reports and other flags

In order to fulfill these functions, each of the above stakeholders needs to participate in network and data coordination. Specifically, they need to have just-in-time access to the up-to-date title record for the vehicle they are reporting on or registering an interest in. Within that functional process, they too are looking for speed, clarity, and confidence from the system.

V. The Case for a Network Approach

Now that we have a strong understanding of the vast business-network context for the digital titling system, we can apply the core design principles and functional pillars from Section III to attempt to formulate an approach. We will endeavor to maximize for robust consumer protection and network coordination, while enabling processes for digital submission of documents and information, interstate transfer, and digital title creation. Importantly, we will remain highly sensitive to the disparate needs, wants, and interests of the business network stakeholders outlined in Section IV.

Before diving in, we should discuss upfront the reason why we think it's best to take a distributed network approach, rather than a centralized clearinghouse approach. The centralized clearinghouse approach has found favor with many for its convenience and expediency. Indeed, the centralized clearinghouse approach should be able to deliver on all of the key pillars and functional capabilities we have outlined. However, the main problem with the centralized clearinghouse approach lies in how it would impact the business network as a whole.

A centralized clearinghouse would have one set of infrastructure, one set of features, and ultimately one set of rules. Therefore, it would greatly undermine the autonomy of each individual state as there would be little possibility of states maintaining individual standards or being able to pilot their own new initiatives, as they do today. Even if all 51 state jurisdictions were able to agree on a single set of minimum standards and business rules – a necessary prerequisite for a truly centralized approach which would likely take years to build consensus for – what happens when a state governor or DMV administrator wants to try a new idea? Our default assumption is that states want to maintain control over their existing sphere of influence, as they do today. Moreover, it should be pointed out that a central clearinghouse approach is particularly vulnerable to the challenges of large bureaucracy, slow iteration, and technology/vendor lock-in. New initiatives for innovation and experimentation would be throttled, and governance would be extremely difficult and slow. None of these challenges are conducive to fostering a landscape of new services, innovation, and expediency around the digital vehicle title.

i) Titling as a Utility Network

It is our belief that the best approach to take in attempting to solve a network-level problem, is a network-level solution. A utility for titling that delivers the level of access, data, and services demanded by each participant type, timely to that participant. We call this approach the Digital Title Network (DTN). Such a network would need to be highly flexible, highly available, and highly authoritative. It would need to be trusted as a primary data source, by drawing its data directly from the participants, and allowing that data to be verified by each stakeholder on a need-to-know basis.

Figure 1 – An illustration of the Digital Titling Network participants and data flows

The diagram above illustrates the concept of the DTN: a single network that all key participants interact with flexibly. When one node (represented by the participant circles) needs data or attestation from another, they interact peer to peer to share and/or update that information, which is then updated for the entire network. In the DTN, privacy is maintained by selective and granular data sharing. Only those participants that are a party to the state of the title at a given time can see any information on it. For instance, for a title with a single owner and lienholder, only that owner, that lienholder, and that state jurisdiction would have access to the title information. However, when the title is transacted between the previous owner/lienholder and a new owner/lienholder, the old pair of interests loses access to the title information and the new pair gains it.

The DTN can best be described as a "network of networks." In this model each state DMV comprises its own network sphere of influence (comprised of dealers, lenders, motorists, etc.) while interconnecting with the larger, national titling network on a peer-to-peer basis as needed for interstate transfers. For *intrastate* transfers, the transaction need not include any participants from other states and occurs within the state jurisdiction's own network and titling ruleset. For an *interstate* transfer involving parties in one or more other states, the state connects with the other state networks directly as needed. This ensures transactions honor the rulesets of the states they occur in, while maintaining data privacy (for instance, of personal or business information) between only those parties involved in the transaction.

Private sector network participants such as dealerships and lenders also operate the same way, connecting directly with the peers they need to during a transaction and maintaining a complete view of their interests (titles and/or liens) across the network for every state they have business in.

The DTN approach fits the scale of coordination needed to become a primary, authoritative, and interoperable source for digital titling transactions. All data which is submitted to the DTN, whether a field indicated on a title application or an attestation given to transfer ownership, is captured from the source, timestamped, notarized, and recorded immutably. Each participant, whether a state authority, a lienholder, a dealer, or an individual, accesses or contributes this source data as they transact peer-to-peer within the network.

Thus, the DTN represents a single, integrated, interoperable network-level solution that serves all digital titling participants and supports all digital titling transaction types. It does this while maximizing for the fundamental digital titling pillars described in Section III and the diverse business network requirements outlined in Section IV.

Let's now discuss the key architectural components that should allow the DTN to meet these goals.

ii) Key Architectural Components of the Digital Titling Network Approach

At a high-level, there are a set of key architectural components we believe uniquely enable the design goals of the DTN:

Distributed Data structure: The data structure must embody robust security measures, ensuring its integrity and resilience against unauthorized access and data breaches. It should be accessible and verifiable on a real-time basis for entitled participants in order to foster a transparent environment where data provenance, immutability, and fidelity is paramount. Each participant has all their transactions recorded in their own private ledger instance.

Framework for Digital Asset Creation: In Section III we outlined how the creation of a digital title asset, not just an electronic record, should be an essential component to modern digital titling. The system should have a framework for creating digital assets that maximizes the utility, modularity, and interoperability of the title asset.

Privacy Preserving Networking Framework: Granular-level access and privacy controls are needed to ensure privacy and ownership of data on the network, i.e., one participant cannot see the transactional data of another participant without being a party to the transaction themselves. At the same time, any two or more participants on the network must be *able* to share data amongst each other, fully peer-to-peer. When a consumer logs into a DMV application, they want to be able to see all of their titles – not just the titles they have in a single jurisdiction. Similarly private sector participants should have a complete view of their business across state lines, but different businesses should not be able to see each other's data unless required on a transaction.

Platform-based Architecture: A platform-approach is preferred in order maximize 2nd-layer utility and functionality. Specifically, the platform architecture should enable a microservices-style application layer. This application layer would be comprised (primarily at first) of the codification of specific business rules tailored to each participant's use case. These new business applications should be built seamlessly and modularly on top of the platform. As the platform matures, applications could be created that draw on

the network's primary data related to vehicle ownership and/or archival information. These applications would compete naturally for end-users, creating win-win incentivization for innovation.

Flexible interfaces: A specialized interface/UX tailored to each participant type is needed to optimize their disparate workflows.

Flexible Data models: The network's data model needs to accommodate for national scope while maintaining the bounded requirements of states. For example, the network should contain a "super-set" of states' titling data models so that titles that move between states will always have the appropriate titling fields in the destination state.

Flexible integration points: Where other applications exist or are already in use for key functional areas; for instance, managing workflows, gathering source data, or verifying source data, the network should be able to easily integrate. Integration points minimize disruptive impact and enshrine optionality for users. Thus, the network's tech stack needs to be able to support and accommodate as many different infrastructures needs or preferences as possible. The goal is to keep technical barriers to entry as low as possible, and simultaneously avoid vendor or skill lock-in that increase costs for everyone.

Taken together, we believe these components form the basis for the DTN approach, creating an ideal modern digital titling solution that can remain open, practical, and utilitarian well into the future.

In the next section, we will dive deeper into the technical and architectural building blocks of the DTN approach. The goal will be to present a sound and concise architectural framework that meets the above requirements. It's time to put our technologist hats on.

VI. The Utility Network Approach Implementation

Over the past two years, we have assembled a team to build our vision of the DTN. We have been in constant communication and collaboration with many states and the AAMVA community, as well dealer groups, dealer associations, fleet managers, auction houses, commercial lenders, captive lenders, credit unions, policymakers, insurance companies, salvage firms, and several major commercial companies in the auto industry. These conversations have driven the business and technical requirements that led to the creation of this complete system for modern digital titling, the DTN. In this section, we will provide an overview and explanation of the technological choices we have made along the way. Our hope is to show you, through demonstration, how the groundbreaking solution we've outlined can be implemented anywhere.

i) System and Networking Architecture

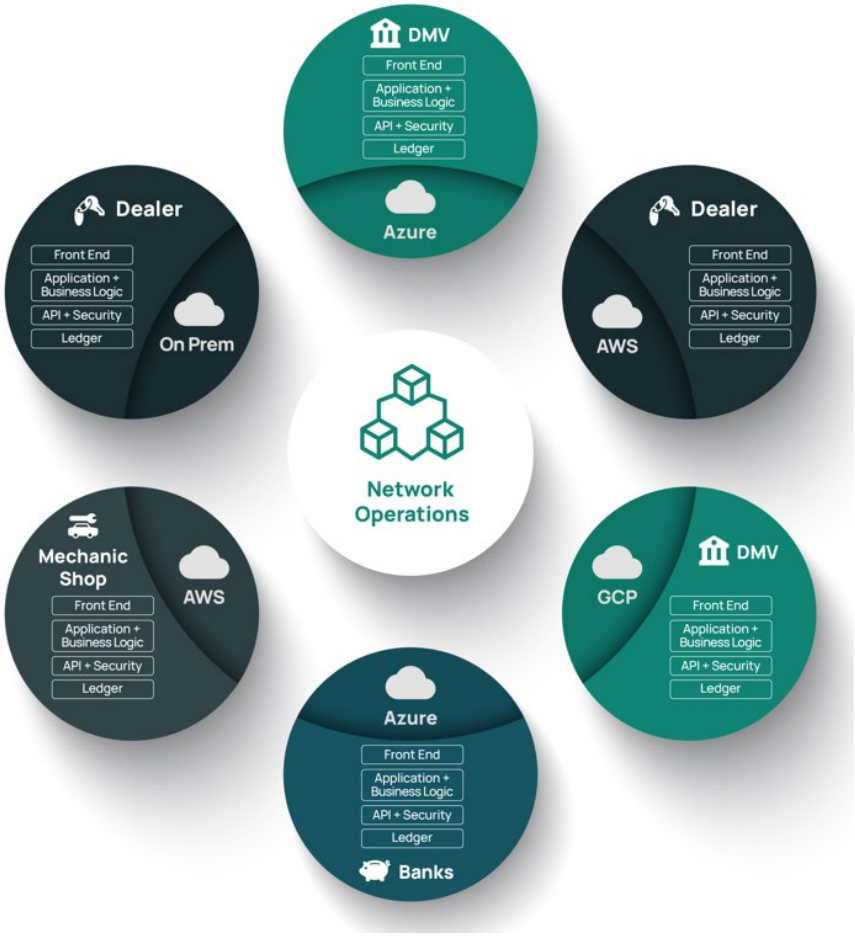

Figure 2 - High-level system architecture

The diagram above illustrates how the solution architecture can be hosted flexibly on any environment a participant chooses, and how each of these applications can be broken down into four basic layers. On the bottom layer of the stack lies the data structure – the distributed ledger. The system utilizes a combination private-public blockchain database architecture. On top of this foundational data layer is a modern API-based interfacing and secure containerized microservices design. The goal of this design is to achieve the high-fidelity qualities and extensible programmatic dynamism offered by blockchains without sacrificing privacy, speed, or support for disparate feature sets. On top of the API and data layer, specific rulesets and business logic are instantiated to serve specific jurisdiction-level and participant-level requirements and/or preferences. Finally, on the top layer are the flexible front-end interfaces, which can be customized to each participant's liking. Importantly, the entire solution is hosting-agnostic, allowing each network participant maximum flexibility in deciding how and where to install and run the application. For instance, in the above depiction, one DMV chooses to host on Google Cloud (GCP), while another hosts on Azure. Meanwhile, one dealer group decides to host the application on AWS, while another large dealer can choose to host on-prem.

The networking architecture can best be described as a network of authorities, participants, and users. Each state DMV runs an "authority" node (the green circles in Figure 2 above) that holds the

authoritative status of a vehicle's ownership information. "Participant" nodes are run by each of the major participants, for instance large lenders, dealerships, or insurance companies, that access this data and submit transfer or update requests as needed. Importantly, these distributed participant nodes each contain a mirrored copy of the authoritative ownership data, but only for those vehicle assets that the node's owner – the particular business or group – has an interest in. End-users (consumers) simply leverage the state's authority to submit titling transactions directly through the state's website (which connects to their authority node in the back end), precisely the same way they log-in to a DMV's online service portal today to renew an out-of-date registration.

Let's examine what a hypothetical implementation of the DTN would look like in a given state: The state's DMV would host an authority node that contains ownership and registration data for all vehicle titles in that state. Meanwhile, a dealership in that state runs their own participant node – on their choice of infrastructure – that contains data for all of the dealership's titles. A large vehicle lender runs their own participant node as well, which contains data for all titles that they own or have a lien interest in.

Now consider a consumer in the state that wishes to sell their car, with an existing lien, to a dealership: The user accesses the application through a DMV-run portal and authentication mechanism, finds their vehicle, and initiates the transfer with the dealership as the buyer. The dealership's participant node is notified, and they receive a mirror copy of the state's data on the title and transaction that was just created. The current lienholder already has the same mirrored copy on their node, but now they receive immediate notification of a transfer. They wait to receive their funds, and then – through the system integration points – automatically release the lien and submit an update back to the authority node. The authority node simultaneously updates the mirrored copy shared with the lienholder and the dealership. Once the dealership is notified of the lien release, they can consummate the transaction with the DMV, which updates its record to reflect that dealership as the new owner. The new title is created on the DMV authority node in the dealer's name and is automatically replicated. The lienholder's node, however, (as well as any nodes run by other dealerships) does *not* see the new record, since they no longer have a business interest in the new title. This illustrates how the network keeps ownership and lien interest data private and secure, even in complex transactions that involve multiple participants.

Had this transfer occurred in "State B" instead of "State A", it would be the State B authority node that makes the updates instead. Had the transfer occurred *between* a State A motorist and a State B motorist, the States' two authority nodes would interact on the transfer. In this interstate scenario the transfer would be initiated by the motorist in State A (the seller) on the State A node, and mirrored to the State B node where the State B motorist would complete and approve it. The old title would remain on the State A authority node but would be voided, while the new title would be created on the State B authority node. The record of the transaction information (the title transfer application and documentation) would continue to exist on both authority nodes. **Importantly, if states A & B have different titling rulesets (for instance, different fee collections) and/or different titling data fields, the authority nodes' specific application logic would ensure the transaction follows the appropriate rules and is created on the destination state's application with the appropriate data fields.**

This system design and networking approach facilitates flexible coordination, transparent sequencing, and selective data sharing to maintain privacy while transacting between any number of parties. Moreover, it does so without sacrificing autonomy, as any state-run authority node can instantiate its own set of business rules for its own titling transactions or processes. Additionally, any state-run

authority node can be easily extended to offer additional services to consumers, for instance specialty plates, without permission from or impact to other nodes. Similarly, commercially-run participant nodes such as one run by a dealership can be customized – without permission from or impact to others – to offer its own services as well, or to integrate into existing company-owned systems or workflows.

ii) Identity and Access Management

Robust identity and access management controls are a must to ensure trust and safety on the DTN. We have discussed the IAL2 standards and requirements for digital signatures, promulgated by NIST and prescribed by NHTSA and AAMVA. Considering the disparate capabilities and preferences among the different state jurisdictions and network participants, we elected to take an approach of maximum flexibility. Processes for identity verification in the DTN can be built or brought in-house, or they can be provided by the platform. We built the solution on top of the leading provider of Identity and Access Management and selected a well-known identity proofing/verification provider (certified at NIST IAL2) to integrate seamlessly into the digital signature workflow.

As states consider their own implementations, they can assess the same set of options. Existing identity verifications services – where these are working well already – should absolutely be leveraged. Where no current service exists, a new service can be stood up and integrated or another existing third-party service can be plugged in.

Minimum standards for identity verification could further streamline consistency and ease of use across the network, but for now flexible integration points can satisfy these requirements at the behest of each jurisdiction.

iii) The Blockchain

Blockchain as a technology has a colorful profile. Most associate the technology with Bitcoin and other cryptocurrency networks, and rightly so – for this is how it gained initial attention and popularity. That said, since the early days of Bitcoin the technology has greatly matured and developed. Today, many major companies and government entities use the technology to help coordinate complex network processes. For instance, the Depository Trust and Clearing Corporation (DTCC) now uses a blockchain-based system to settle millions of equities trades a day on the Corda blockchain framework[8].

Blockchain networks are distributed computing platforms that use a consensus mechanism to coordinate around a single source of truth database. The consensus mechanism is what ensures the fidelity of the distributed database (or ledger), enabling nodes to plug in seamlessly and verify pertinent data without having to download or run the entire database.

Most of the confusion around the feasibility of blockchain technologies for business use cases can be traced to an understanding of different consensus mechanisms. To explain this, we must first differentiate between “private” blockchain frameworks, such as Fabric or Corda, and “public” blockchain frameworks such as Bitcoin or Ethereum.

The central question of a blockchain system is: who can read transactions on the network? And who can write transactions to the network? For a public blockchain, the answer to both questions is “anyone”. On Bitcoin, anyone can view any transaction ever made, and anyone can set up a node to start maintaining

[8] https://r3.com/press-media/dtcc-selects-corda-for-project-ion-platform/

the database itself. This means the network needs a highly intensive consensus mechanism (known as proof of work) to ensure these anonymous actors are trustworthy before they are allowed to write transactions to the high-fidelity distributed ledger. This creates bottlenecks in processing speed, performance, and system requirements.

On the other hand, in a private blockchain network, the answer to these questions is “only registered, authorized parties”. Private networks form around real-world use cases where data privacy is important and permission to join or use the network is required and managed (i.e., where permission is needed from the state in order to update a vehicle’s ownership). Thus, private networks maintain granular-level control over who can read what data, and who is allowed to write data, on the distributed ledger. This requires a much lighter form of consensus, since only known quantities are allowed to request updates from the network. In Corda - our private blockchain framework of choice – this consensus mechanism needs just a single node and one neutral notary service to validate transactions deterministically. This allows the network to achieve extremely high performance and scalability, up to tens of thousands of transactions per second. More than enough performance to satisfy even national-scale digital titling!

All of that said, there are some important qualities of *public* blockchains. Most notably, they are highly accessible – allowing anyone anywhere to verify data recorded to them, and extensible – allowing for highly modular applications. Digital assets on public blockchains have incredible amounts of utility and future potential, and because of their low-cost of integration and public-verifiable nature they are the perfect application layer for the self-sovereign digital title. That is why for the DTN we propose a combination private-public blockchain approach, maximizing the private networking and performance of private blockchains with the open verifiability and utility of public blockchains.

Although the DTN uses this combination private-public approach, it is important to keep in mind that all transactions are conducted within the private blockchain network made up of authority nodes and participant nodes. Once a transfer of title transaction is completed, the new digital title is created on the authority node of the respective state, and then mirrored out to any participant nodes that have an interest in it, for instance to a lienholder with a security interest. The title record in the private network acts as the authoritative source of truth maintained by the DMV and is automatically pushed back to the DMV’s system of record. A rendition of a digital title held on the DMV’s application is shown below:

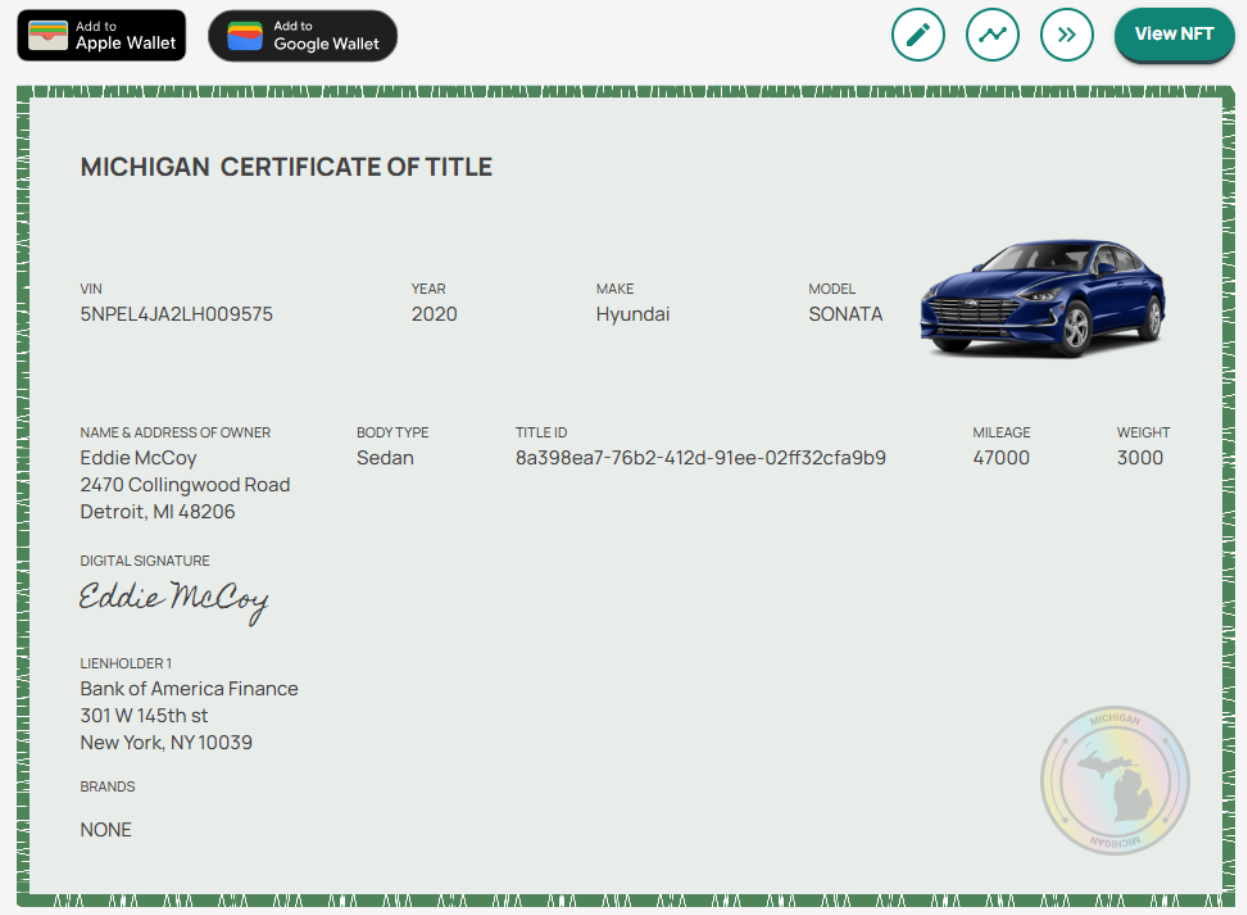

Figure 3 - Digital title held on the private network on the DMV's authority node

Since this title is held at the DMV and only accessed by the owner through the DMV site, it shows the regular title details that would be seen on a title today, including the owner's personal information, the lienholder information, and various elements of the vehicle information.

In addition to this, a linked *digital title* record (minus any sensitive or identifying information) is also created on the public blockchain network. This represents the owner's digital bearer asset, also called a Real-World-Asset (RWA) or Non-fungible Token (NFT). To house the RWA, there are many public blockchain networks to choose from. We chose one called Polygon, a 2nd-layer network built on Ethereum, for its performance and also because the Ethereum ecosystem is the largest public blockchain network, which maximizes opportunities for future innovation. Below is a rendition of a real digital title asset created on the public blockchain network.

Figure 4 - An NFT Title on Polygon, with no PII or sensitive information

The QR code seen on the digital title asset can be scanned by anyone to verify the title is legitimate, current, and was issued to the user by the state DMV authority. Since the digital title asset is publicly accessible and verifiable. it is important to point out the fact it does not contain any PII (e.g., owner name and address) or business sensitive information (e.g., lienholder name and information). All sensitive information is safeguarded on the private network run by the DMV.

A bridge between the private Corda network and public Polygon network ensures that the two digital title representations always remain in sync, with the Corda private network comprising the state authority nodes as the key source. When titling statuses are updated in the Corda private network – for instance as the result of a transfer of title between any two network participants – the resulting status is pushed to the Polygon public network, creating or updating the digital title asset there. The bridge works both ways, so that future applications on the Polygon public network would also push updates back to the authority nodes on the Corda private network.

It's also important to point out that the digital title asset can be held on a traditional non-blockchain phone wallet – such as Apple Wallet or Google Wallet – as a pass, where it be made to show the owner's name (with no other PII) and above QR code.

Let's return to our Key Architectural Components from Section V.ii, and examine how the combination private (Corda) and public (Polygon) blockchain approach allows the system to best meet each one:

Distributed Data Structure: The cryptographic verifiability of each set of transactions ("block") in a blockchain database means that data can be easily distributed and verified to ensure it hasn't been changed and bears the original, timestamped attestation of the signatories.

Privacy Preserving Networking Framework: The Corda private blockchain framework uses granular "virtual node" accounts[9] to manage access to data between and among different network nodes. Practically, this means that DMVs, dealers, and lenders alike can choose to share data privately peer-to-peer on an as-needed basis, while individual motorists can access network-wide data pertinent to them (for instance, digital titles held in multiple states) through a DMV's single access point.

Platform based architecture: Blockchain databases enable programmatic rulesets that are highly modular. This allows for a highly flexible, extensible, and functional application layer to form.

Framework for digital asset creation: Blockchains are the de facto technology used for the transfer and management of native digital assets today. The Public blockchain in particular excels at this since it enables assets to be openly and instantly verifiable. This is evidenced by the hundreds of token standards listed on Ethereum and Polygon[10], with more added practically every week.

Flexible interfaces, data models, and integration points: The use of blockchain as the underlying data layer does not necessitate the use of any one interface, data model, or API specification. These can be built, extended, or customized at will by any of the participants.

The Corda private blockchain also provides some additional features out of the box that would not be possible with a standard relational database.

Availability: Due to its distributed nature, blockchain data structures enable extremely high availability across the network.

Differentiated Rulesets: As we have discussed, blockchain data structures allow us to customize business rules at a granular level, allowing each state jurisdiction authority to execute titling transactions against the state (or county)-specific rulesets of their choice, while still allowing for large scale national interoperability.

Granular Data Residency: The blockchain system's networking framework allows data (e.g., titles) to reside only in or with the jurisdictions and participants that own that data, and nowhere else.

iv) Future Technology Considerations

The pronounced focus on network-interoperable technology and digital assets is to future-proof the network. Before the first paper workflows migrated online, few could imagine how applications like Excel, Google, and Zoom would change the way we work. Fewer still would have believed that ecommerce solutions built on top of those rails would grow to be able to deliver us anything we wanted from all around the world in less than a day.

The corollaries here are open APIs that facilitate authoritative ownership and title data, and "internet of value" applications that could interact directly and *programmatically* with a user's digital title asset. Let's

[9] https://docs.r3.com/en/platform/corda/5.0/key-concepts/cluster-admin/virtual-nodes.html
[10] https://eips.ethereum.org/erc

start with why open validation of vehicle titles, like that which could be offered seamlessly by the DTN to any user or participant node, would be so transformational.

Open API specifications today represent a forward-thinking design choice for data providers. They are an excellent way to streamline the sharing of critical information with business entities and public stakeholders that rely on such data. These open interfaces facilitate interoperability and integration, ensuring that data can be accessed in a manner that is both secure and efficient, without compromising the integrity of the data or the privacy of individuals. This approach not only accelerates innovation by enabling third parties to develop new services and solutions but also enhances transparency, a crucial aspect for public trust and accountability. Furthermore, open APIs empower users by providing them with the freedom to choose from a variety of applications and services that best meet their needs, promoting a competitive ecosystem. The adoption of open APIs, therefore, is a strategic move that aligns with contemporary digital transformation trends, ensuring that critical data is readily available where it is most needed while simultaneously fostering a collaborative environment that can adapt to future technological advancements. On the DTN, state authority nodes would be able to seamlessly allow for the validation of vehicle ownership through an open API-style service to participants.

The repercussions of this for the business network are significant and multifaceted. It builds user confidence in the digital services they utilize from any participant that, as a mirror node, transparently gets its source data on vehicle ownership and history from the authority nodes and is always highly available. It deters malicious activities by presenting robust barriers to unauthorized access or fabrication of any sort of title-related information. And finally, it enables a digital ecosystem of applications that could consume this validated ownership information to provide new value-add services.

That brings us to the concept of the internet of value. It sounds like a buzzword, but what it really refers to are internet-native applications that can transact directly with digital wallet infrastructure and digital assets. Imagine a simpler online transaction method: instead of inputting extensive payment details like credit card numbers, addresses, and birth dates, you could just tap your phone on a kiosk or link your wallet to an app. This allows the app to verify the asset's legitimacy, be it funds in a wallet account or a digital title authorized by the DMV, without risking your personal data.

Indeed, in 2023 the number of Apple wallet users in the US reached a new high of roughly one in every 5 consumers, and this represents an astounding 800% increase since 2015[11]. While not yet on par with Apple or Google wallets, digital (public blockchain) wallets such as Metamask, Trust Wallet, and Coinbase wallet are gaining adoption steadily as well, especially among younger consumers[12]. These public network wallets have one of the most open and extensible programming spaces, with new applications popping up in the ecosystem almost daily. In the blockchain ecosystem, non-fungible tokens or NFTs are used to represent two different kinds of unique assets, digital native assets that exist only electronically and real-world assets. It’s this latter category of RWAs where the future opportunities lie for the DTN. The creations of these “digital twins” of the Real-World Asset (RWA) allows for huge opportunities of functional expansion. These RWA NFTs can represent data, property, credentials, or physical assets. They are instantiated as part of “smart contracts” that govern the properties of the NFT(s). As such, these

[11] https://shorturl.at/goR45
[12] https://shorturl.at/sLSU8

assets are highly programmatic, modular, and extensible. At time of writing, there are hundreds of unique NFT implementation specifications posted to Ethereum's open-source development repository[13].

Here are just a few examples of tangible use cases that could be enabled by the digital title: A consumer that has received a valid digital title from a state authority node could add that title to their phone wallet as their own digital asset and proof of vehicle ownership. They could then, for instance, access a marketplace for external applications that consume the title asset in some way, for instance taking out a loan. Today, financing loans can be slow and expensive for lenders who have to verify ownership and then use ELTs to communicate changes back to the DMV, who then have to ensure the lien is being honored and enforced. In the future, a consumer could simply reveal their title asset to the lender's application, which verifies it has been signed by the DMV. The application can then execute a loan contract against that title, collect the consumer's attestation through their wallet (which is enabled via biometrics), and update the data on its mirror node. The mirror node then instantaneously reflects the update back to the DMV node, which can automatically verify the signature of the lender and the signature of the consumer's wallet that was issued the title. Notice how no personal identifiable information need be revealed through this process, heading off potential identity-spoofing scams. All that matters is the credential in your biometrically enabled wallet on your phone.

Digital wallet infrastructure has continued to improve. Many DMVs have been proactive in implementing Mobile Driver Licenses (MDLs) as official credentials that can be stored seamlessly in a phone wallet. In Georgia, the world's busiest airport is now piloting digital identity credentials such as these in security lines[14]. Many of these strides are thanks to the foresight of the DMVs' many MDL programs. Similarly, future applications could seamlessly interact with a digital title asset to verify the DMV and the owner's signatures, and even see key data about it such as verified ownership history, the presence of a lien, or the last odometer statement reading. Certain applications can even provide a real-time feed to the vehicle's data (such as the real-time odometer reading) once the owner verifies their consent through their digital wallet, enabling connections for reimagined services such as for car insurance[15].

As states move forward with implementing digital title systems, they must ask themselves if they are doing what they can to enable future innovation such as this, if only to prevent having to procure entirely new systems or capabilities in the future. This is one of the reasons why so much emphasis is placed on the DTN's distributed architecture and the digital asset platform that it supports.

VII. Conclusion & The Path Forward

Across the country's many state jurisdictions, today's e-titling capabilities are highly varied. Motorists in Arizona, Virginia, and Utah are able to complete certain C2C e-titling transactions online and hold their title digitally with the DMV. Dealerships in Texas, Georgia, Michigan, and Ohio can submit titling paperwork for certain transactions electronically and hold an electronic title at the DMV. In 30+ states, lienholders can communicate the addition and release of liens with the DMV through ELT systems. Still other states such as West Virginia, California, and Kentucky are moving forward with futuristic initiatives

[13] https://eips.ethereum.org/erc
[14] https://www.tsa.gov/news/press/releases/2023/05/18/tsa-enables-georgia-residents-use-mobile-drivers-license-or-state-id
[15] https://cleantechnica.com/2023/02/28/dimo-founder-andy-chatham-on-data-driven-cars-more/

involving blockchains. In parallel, AAMVA researchers are conducting a two-year study in an attempt to put forward national standards, requirements, and technology guidelines.

In light of the variance in capabilities and approaches, how can the vision for a single, comprehensive, and national DTN feasibly materialize? We don't know for sure, but we can confidently offer some ideas.

Recall how we first described the DTN as a "network of networks", with each state jurisdiction presiding over its sphere of influence while interconnecting with other jurisdictions as needed. Under such a model, each of the state-controlled networks within the larger DTN need not use the same rules, technology, or systems to be able to work together when they need to. While certain minimum standards would still be highly beneficial or even necessary, other differences in approach, technology, or system design need not preclude the exchange of key source data between disparate systems. Key design concepts such as open API specifications for non-sensitive information would go a long way toward bootstrapping a baseline of cross-network verification.

As states modernize and DMV administrators iterate on what works and what doesn't, it is likely that digital tilting will converge to some standard, but in the meantime, states opting for the DTN approach need not wait any more than the leading pioneers have (such as Arizona, Georgia, Texas, and others) to begin their journey.

For states well on their way in the journey and/or on the leading edge, we hope you can draw from these ideas some core design elements that can minimize any costly change orders down the line, as capabilities and technology evolve into the future. Whatever solution or set of solutions ultimately emerge, our belief is that the need for transparency and demand for functionality around a digital bearer-asset title will lead to something that would in many ways resemble the DTN structure: a network of states and large institutions made up of smaller, more localized but still intertwined networks that exchange digital title assets point-to-point. Nonetheless, it will be our collective vision for what digital titling *ought* to be that drives us towards the best outcome in those many years ahead.

In a scenario where the DTN is widely adopted, we imagine a future where titling is no longer a hassle, but a functional utility. Transfers of title that used to take weeks and months can now be conducted near-instantaneously and with nearly zero possibility of human error. Fraud of all sorts is largely obsoleted, DMV and dealership staff eliminate irksome paperwork – saving millions of pieces of paper, and new applications and services of all sorts are enabled through the foundation of the digital title with bearer-asset quality. Our vision is that a vast DTN would imbue the national and global automotive ecosystem with real-time, flexible, large scale data coordination, enabling even better efficiencies, protections, and innovative services that make a difference for the hundreds of thousands of businesses, and hundreds of millions of Americans that make up the United States' vast automotive community.