# Product Vision and Overview for Koyote Science, LLC

**February 11, 2022**

**TL;DR: We believe that the future of building responsive products and internal decision-making will be based on ensembles of cheap, easy-to-use bandit and reinforcement learning services.** We want to be the Levi's to the AI gold rush, the first name that comes to mind when someone wants to close the model-building and data collection feedback loop. Here we outline the potential market fit, value proposition, enterprise fit, intellectual property, competitors, and future growth directions for Koyote Science, LLC. We recognize that this document describes a $100 billion company, since we are founded on extremely powerful technologies that are fundamental to the future of business. Rather than begin as an end-all-be-all solution to product building and AutoML, we plan to bootstrap off of one low-hanging fruit market to build experience and engineering infrastructure, and grow from there. Over time, we should be able to spin off as many products as we see fit and to adapt to market and technology changes as we grow. For now, we discuss what is possible.

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Koyote Science, LLC and the *Bandito Suite*™ of reinforcement learning-based APIs are well-poised to take over the following markets:

- **Marketing funnel** optimization
- **A/B testing** optimization
- **Personalization and recommendations** with collaborative, content-based, and hybrid filtering
- **Similar user and item search** based on how users consume content
- **Micro-personalization**, i.e., enhanced interactivity on top of traditional methods
- **Chatbot policy**, covering which questions to ask and in what order
- **Interaction flows**, such as sign-up, new-user, and general interaction flows
- For offline model development:
    - **Hyperparameter tuning** which is particularly important for deep learning
    - **Active learning** when data collection is expensive, such as when data is sourced from mechanical Turk
- While we focus on helping build products that learn from their customers to improve their services in real-time, i.e., the bootstrap data feedback loop, all of our technology is compatible with traditional supervised learning over supplied static datasets, i.e., **AutoML**, which is the main course for our competitors that we could ultimately replace
- There is growing interest in **causal inference** in business applications that is stymied by bespoke technology and challenges recording data impressions correctly. Any

organization using our suite of products will be able to centrally manage the necessary book-keeping, dramatically reducing time-to-deployment of applications in this space.

Our **value** propositions include:

- **Knowledgeable leaders** who can facilitate integration, with proven experience in:
    - **Advising the C-suite** at large companies in a data science capacity on both the product/user side (Twitter) and the sales/marketing side (Pinterest)
    - **Leading engineering teams** to build successful products (Twitter and Amazon Alexa)
    - **Productionizing** multiple models critical to product success (Amazon Music)
    - **Investing in the substantial foundational work** while **possessing the courage to rip out legacy infrastructure** to innovate, making new product categories possible, which has lead to advising top-company executives on their future product direction (Amazon Alexa Skills Developer Kit, see Music Conversations)
    - **Academic writing and networking** to keep abreast of the latest innovations, with the credentials, experience and drive needed to turn those innovations into real-world impact
- **Contacts** within the top tiers of industry and advisors who know what they're doing at Lyft, DeepMind, DoorDash, Amazon, Twitter, Insight, Nvidia, and Google
- **Correct** implementations that have been well-tested, written with readability, modularity, and convention in mind to facilitate future growth and debugging
- **Efficient** code and small footprints allow us to deploy APIs on cheap, secure, and easily-maintained services such as AWS Lambda
- A **common API interface** to common tasks within a company, which means that one group of employees can maintain the code and the server rather than having a hodgepodge of implementations consuming labor in various divisions
- A **modular design** built using modern OOP design patterns in Python 3.8 that makes it easy to integrate into a variety of tasks.
- Support for **offline model training** and then importing the best-performing models to run data-collection and real-time interaction. This helps instill trust, since the customer has total control over the models they deploy.
- Support for **advanced deep learning** models and GPUs is already built-in, using Google's auto-differentiation tool JAX, which has a small footprint and allows us to host these models cheaply.
- **Self-tuning** services that dramatically reduce the need to spend labor on offline tuning, allowing our models to bootstrap from small amounts of data and transition effortlessly

to high-quality predictions on large data lakes. This approach can be likened to automobile automatic transmission in a world where everyone can only imagine fixed-gear or manual transmission at best.
- **Feature transformation** is a breeze with our software stack, which is a major labor sink for these kinds of products. Designed by an accomplished machine learning practitioner, our software makes it trivial to switch between discrete (e.g., categorical) and continuous features, as well as discrete and continuous actions. We have integrated the scikit-learn feature transformation pipeline to rely on its robustness, documentation, and excellent design.
- We can **use our own products** to bootstrap our success. As we gain more clients, we can repurpose specially-built code from one project to another, and market the success of our current clients to grow our user base. When you grow the pie, everyone wins.

These value propositions allow us to target different business clients along the following break-down:

- **Small companies** can enjoy:
    - An emotionally intelligent and experienced leader who can earn their trust, with a history of impact on multiple functional units within their business
    - Entry-level versions of our products that get them on their feet and building amazingly responsive products as quickly as possible
    - Enhanced marketing and lead funneling
    - Faster, more intelligent A/B testing to bootstrap new products quickly
    - Personalization, recommendations, and enhanced interactivity from the get-go
- **Medium-to-large companies** additionally enjoy:
    - A unified framework for multiple tasks that are currently siloed in different groups
    - Enhanced interactivity on top of established recommendation and personalization modeling that they have already built
    - Higher-performance and more-efficient offline model development

While built for robustness and ease-of-use, the *Bandito Suite*™ has **room to grow** for our most-demanding customers, including:

- Future integration with the **latest reinforcement learning algorithms** as they are programmed and distributed through open source through RLlib and CleanRL
- Support for specialized models can be made available as needed

    - **natural language processing** (NLP) models for text
    - **feature extraction models for images** and photos
        - Note that featurizing image data will require additional engineering due to the data and latency requirements, and may need GPUs which are expensive
    - First efforts using popular pre-trained models (e.g., Hugging Face BERT NLP models or ResNet50 image models) will have decent performance that can be improved with specialized efforts; these efforts can be carried from project-to-project creating a network effect, depending on data security needs
- Future development of **advanced visualization dashboards**, model monitoring, social networking over model development a la Huggingface, etc., however this is a crowded and somewhat mature space, so partnering with current offerings may be preferred

At the moment, our current **intellectual property** includes:

- **Academic treatises** on the underlying math that powers our products, providing credence to our methods, answers to technical questions that may arise, as well as making it straightforward to teach clients and new employees, a major tool for cultivating trust. Such writings and presentations grow the pool of customers excited to develop new, robust and responsive products that will need our services, as well as genuinely motivate our developers for the value of what they are making, something that money can't buy. The treatises cover:
    - Exactly-solved Bayesian models, which provide a standard candle for prediction uncertainty which is used to drive the exploration-exploitation trade-off in all of our products
    - Real-world reinforcement learning, presenting a structured approach for building a reliable sequential planner as a natural extension of the bandit formalism that underlies our products. This is the stuff that solves chess and Go, but applied to our customer's unique challenges.
    - Bandits and recommender systems, how reinforcement learning can be combined with collaborative filtering to build robust and responsive recommender systems, and how bandit services can be chained together to create hyper-responsive customer-facing products
- **Software demonstrations** including:
    - **"Blue pill, red pill"**, which shows how a headline or single interface element can be optimized with Bandito. See Microsoft Personalizer's demonstration for comparison.

    - ***Fret Ferret*™**, an AI-assisted trainer for the guitar which is freely available to the public and has been submitted to the SIGCHI and SIGGRAPH conferences.
    - ***Smart Slideshow*™**, a Shopify plug-in app that automatically ranks content in the popular “carousel” or “slideshow” website design pattern
    - **A simple dashboard**, accessible from “blue pill, red pill” and *Fret Ferret*, showcasing how our service can be inspected as it learns and optimizes
- The **API software** itself, including:
    - A highly-efficient, low-latency contextual multi-armed bandit service called ***Bandito*™** which is ideal for single-step customer-facing applications where responsiveness and quick learning are key
    - A highly-accurate, *high*-latency contextual multi-armed bandit service called ***Bandito HP*™** which is ideal for single-step *non*-customer-facing applications where finding the diamond in the rough is paramount, such as offline hyperparameter tuning for machine learning models
    - The world’s most-advanced personalization and recommendation product called ***Bandito CF*™**, which simultaneously recommend items to your customers while improving your signal for future recommendations without any feature engineering at all, using the full force of collaborative filtering married to our other technologies
    - A sequential planning serviced called ***Bandito Sequence*™** which leverages the *Bandito*™, *Bandito HP*™, and *Bandito CF*™ interfaces to optimize not just for a single step, but over sequences of steps aiming at longer goals, such as completing a sign-up flow
    - The ***HyperTune*™** and ***HyperTune Express*™** systems, which augment the entire *Bandito Suite*™ by training multiple models behind the scenes and swapping them out as they learn and optimize for the current amount of data they have collected.

Let’s take a quick look at **our top competitors**. While they have invested many years into their products, marketing, and word-of-mouth, we are still early in the game, and can easily overcome them. Given that we have a common interface and technology for all elements that these competitors tackle individually, we can innovate quickly and decisively. Let’s dig in:

**APIs**

- **Microsoft Personalizer** on the Azure service directly competes with our vision for *Bandito*™, offering a personalization API service that is tied to their cloud products.

While mature, this product is bogged down by the culture of an older company, and apart from engineering and documentation sugar, it offers a very bare-bones service that we can easily out-innovate. Microsoft is pushing AutoML across their entire Azure services, and we can learn a lot from what they are attempting to accomplish.

- Meanwhile, **Amazon Personalize** for AWS directly competes with *Bandito CF*™ and Recombee (see below). They have the worst marketing/documentation but the best security and AWS integration is a plus. Their articles make it very unclear how their product addresses real-time updates and data collection. Note that Amazon AWS Sagemaker RL is a highly labor-intensive, low-support generic effort.
- **Recombee** is a recommender service API very much like what we envision with *Bandito CF*™. They've thought through a lot of features to match different use cases such as "Diversification models (recommending variety of different items), popularity-based models (long-term or trending), [and] reminder models or models periodicity-based models (based on repeating behavior in user-item interactions)", and each one is easy to reproduce ourselves. We like their marketing around image and text auto-featurization, which again is a plug-and-chug kind of thing, and probably doesn't work as well as you'd like. Their marketing is good but too technical.

**AutoML**

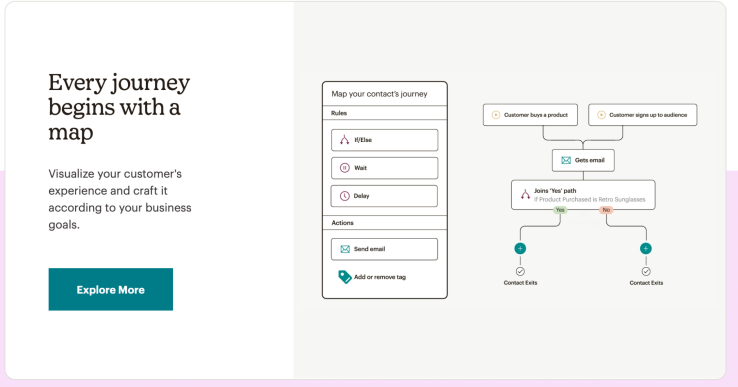
- **Weights & Biases**
  - The world's leading model deployment and monitoring software, supported by a company valued at over $1B, offering website hosting and automatic logging of model performance to facilitate collaboration among ML teams. Note that their logging value proposition is mostly in ease-of-use and automatic server hosting, since the logging mechanism is extremely simple as the developer passes the information explicitly.
  - They also offer hyperparameter tuning which depends on open-source libraries such as Hyperopt, Keras Tuner, Optuna, Ray Tuner, Scikit-optimize, or BayesianOptimization (similar to *Bandito HP*™ and SigOpt)
  - We can integrate with these services or compete with them directly. Note that W&B would likely not scale for our purposes or fit our needs perfectly, but we can set up a demo and hire an engineering team to build better dashboards, since that's one of the easier parts to hire someone to do.
  - Also see Neptune.ai.
- **SigOpt**, which was recently acquired by Intel, is a hyperparameter tuning service similar to BayesianOptimization and *Bandito HP*™ that has recently expanded into the model

visualization and monitoring space. They're now competing directly with Weights & Biases and just had a SigOpt summit. While their hyperparameter tuning capabilities exceed that of W&B, it's clear that they are behind W&B in most other respects, including marketing, capabilities, and visual design.

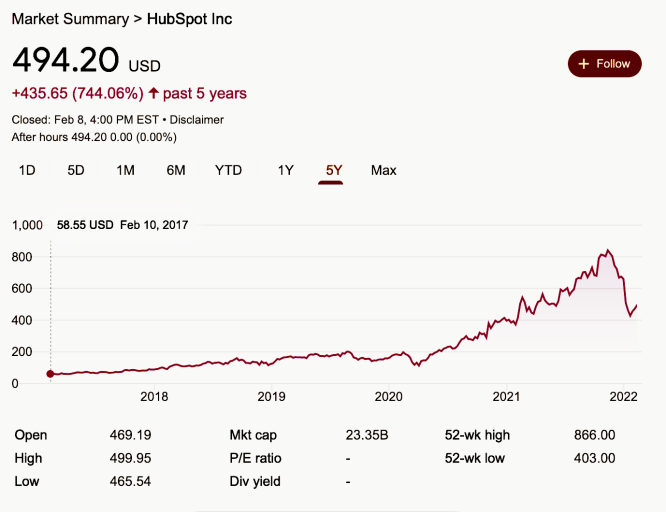
- **C3.ai** is a comprehensive set of AI/ML tools for enterprise customers, with a lot of emphasis on visualization, model tracking, data integration, and specialized applications. Very slick, probably overwhelming, and their stock is taking a wild ride since they are seen as a canary for enterprise AI as a whole. They even have that same weird model visualization that W&B and SigOpt have to help with hyperparameter tuning.

**Sales & Marketing**

- **Mailchimp** multivariate campaign testing provides the opportunity to run a Bandito-esque campaign, working with up to four variables per email (from line, headline, content variation, and send time) to optimize newsletters, and can optimize either the open rate, click rate, or revenue. Their implementation does *not* use and bandit service, however – the customer chooses how long to run the testing phase (pure exploration) and then switches to pure exploitation. The customer can also just choose which combination of features they prefer to exploit. This functionality is only available at the Premium tier at $299/mo., and simpler versions with fewer features are available at lower-cost tiers. Other offerings from Mailchimp at a lower rate:
    - Send-time optimization
    - Customer journeys
    - Subject line helper
    - A/B testing at the lower tier

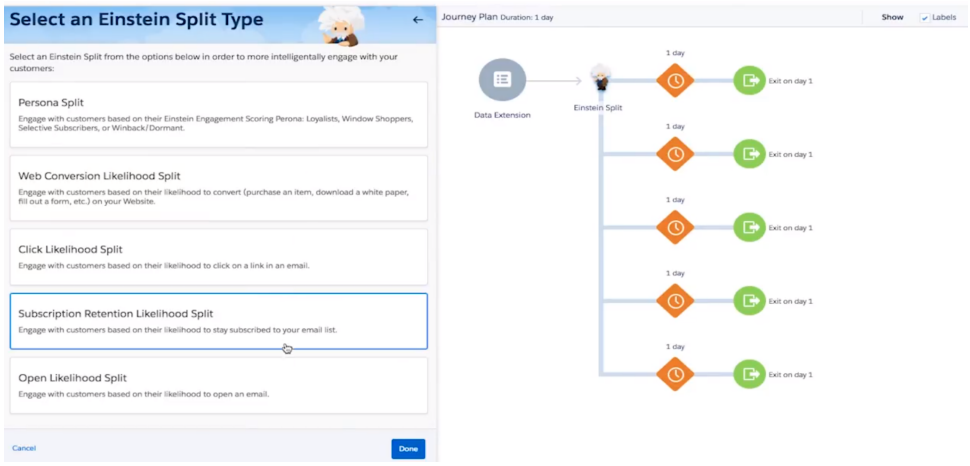


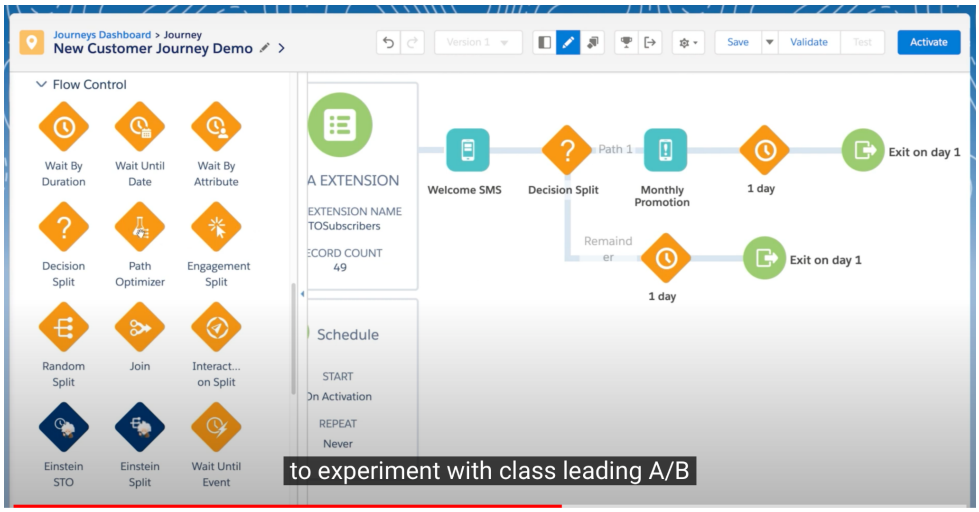
- **Hubspot** app exchange has over 80 plug-ins purporting to offer "optimization". Here are the highlights:
    - Split Test Automation – Similar offering to Mailchimp
    - Seventh Sense – Another time-of-day optimization between users and time-of-day rather than just globally, and with some capability for limiting how many get sent at once to avoid getting too many calls back at once
    - Personalize – Lets the shop owner tag pages on their website, then use audience cookies to customize email content to the categories of the pages they visit. This one is overpromising.
    - Justuno AI pop-ups and CRO tools – claim to have some means of optimizing the pop-ups they display
    - **Unbounce** landing page optimizer – claims to optimize the content of your landing page for greater ROI. See Smart Traffic and their demonstration video. They have the most installs of any competing app in this segment and recently raised over $40M in Series A. Honestly, their video hits the nail on the head, making them a worthy competitor, but we can grow and hit markets in ways they likely can't.
    - Hubspot has a market cap of $23 billion and a strong stock profile, seeing a 10x value increase since April 2020:




- **Salesforce** App Exchange and Marketing Cloud allows users to create journey paths based on engagement. Pay attention to:
    - Path optimizer, which performs crude A/B testing similar to Mailchimp,
    - Einstein Split which trains models on users to segment them by various metrics and allows you to manually split your journey along those segments,

- Einstein STO which uses ML for send-time optimization. While the Einstein products use machine learning, they are not using a feedback loop like A/B testing does
- ROBO-X email campaign optimizer claims to do more, and even advertises “explainable AI”, but doesn’t provide a clear view so it could be hocus pocus.




Various companies have integrated services similar to Bandito but only behind-the-scenes for their customer-facing products. Here we list a few prominent examples:

- **Optimizely** Stats Accelerator for A/B testing optimization. That’s about it. It’s part of Optimizely which is the primary selling point.
- Google Adwords' "Ad Rotation" optimizes A/B testing for their lucrative advertisement product, and is limited to this application only
- New York Times article optimization

To provide a complete product, **we will need to build out the following**:

- **AutoML**, i.e., automated model deployment
- **Dashboard visualization** for model progress monitoring
    - A simple example has already been built, but this can be greatly enhanced.
    - We may decide to integrate with dashboard tools like Tableau instead
    - See SigOpt, Weights & Biases, and Neptune.ai product demonstrations for comparisons
    - Note that **we may have special visualization/dashboard needs** that the above companies cannot provide.
    - Providing a dashboard will require building a database model for historical logs, since it will be impractical to store those with the models used during inference
- **Integration** with a data ecosystem, such as Salesforce
- **Marketing**
    - Recombee has excellent marketing, although it skews too technical
    - Weights & Biases highlights customers to other customers, capitalizing on a network effect that we can use too
- **Documentation**
    - see Weights & Biases, which has the best documentation in the industry and puts AWS to shame
- Larger applications will need **concurrency** handling – this is an intermediary API that collects data over regular intervals and sends them to our APIs all at once
- An **extensive unit testing** suite to ensure each element is working as intended. We have early prototypes ready.