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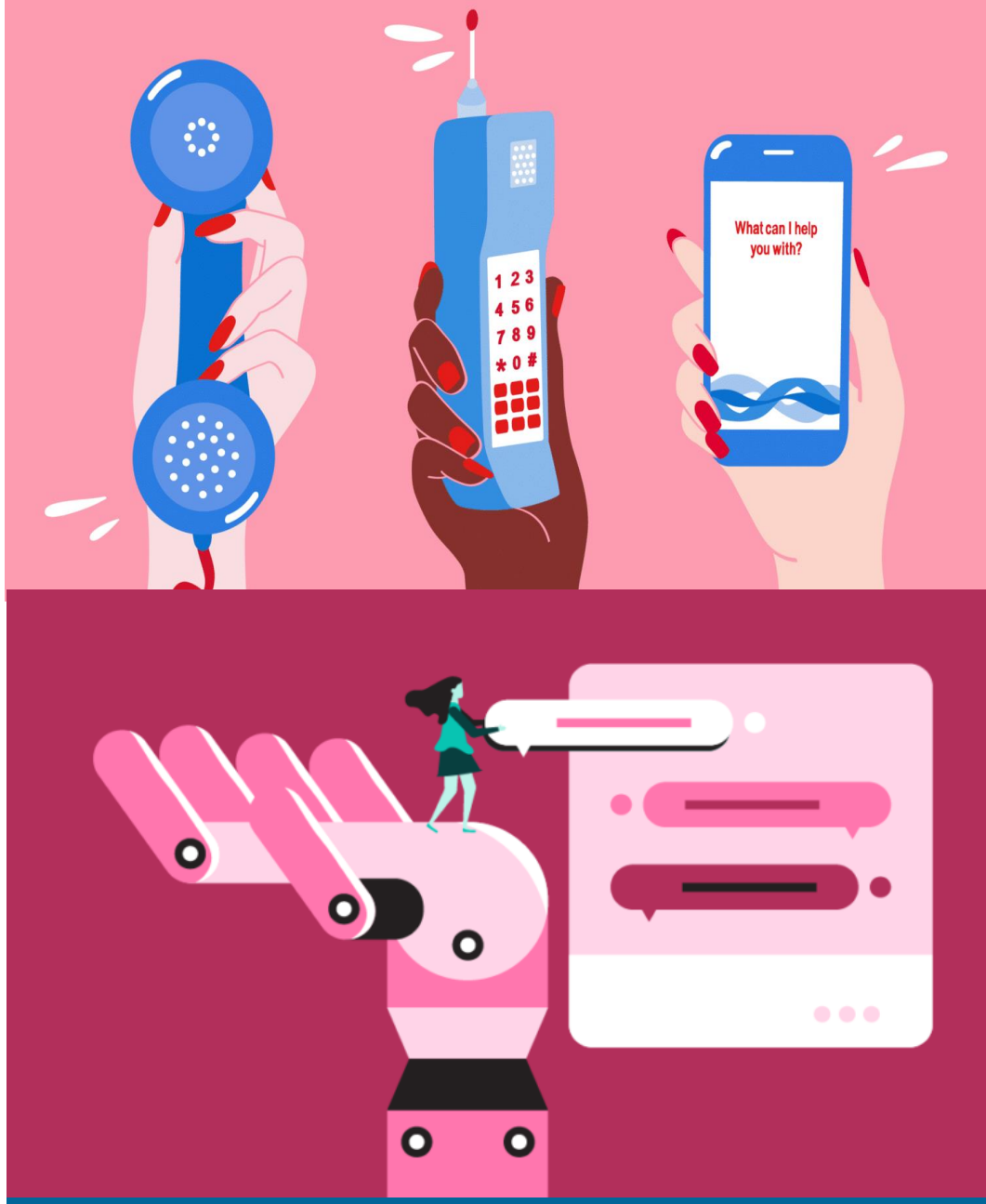
DigITs

DIGITAL, INFORMATICS, TECHNOLOGY

Exploring IBM Watson as a product to conversationalize surveys

Tech Incubation Internship, Summer 2020

Christie Yu



June - August 2020

Acknowledgments

What a support system!

Thank you very much for your help!

- **Kristine, Divya, and Dr. Stein**, for continual project management support
- **Ricardo**, for being the project's engineering backbone
- **Monica Allison, Wynne Kim, Zach Rachlin, and Priti Parekh**, for situating me with Engage & Knowledge Bank
- **Naveen, Eric, and Mac**, for onboarding me with IBM Watson
- The **TechInc** team, for teaching so much about discovery, exploration, and SOTA of conversational interfaces
- **Hal and Ethan**, for a great summer!

Personal learning goals, revisited

The fastest 3 months of my life

What I wanted

- Designing for humans (UI/UX)
- Ownership of engineering project
- Project management... what is it?
- And then maybe I can figure out what I want to do in the future?

Never got the chance to take a group photo :(but here is Hal, Ethan and I in about 3 pixels each

What I got

- Agile & iterative project design
  - Timelining, defining success metrics, documenting blockers and areas of further exploration
- Full-stack, IBM project engineering
  - API's, SQL databases, webhooks, IBM functions, AI/NLP/ML, GitHub collaboration
- Forward-thinking technology design
- Insight into small, full-stack team coordination
- A true appreciation for digital healthcare work
- Lots... and lots... and lots of slide decks

So what did I do?

MSK is interested in pursuing IBM Watson as a vendor for conversational interfaces.

My project explores how we can create an accessible touchpoint for MSK Engage in the form of a mobile survey conversational agent.

Users can complete required forms on-the-go with an assistant that will authenticate them, direct them to their list of to-do surveys, and collect their responses to the existing Engage database.

A mobile survey conversational experience will save patients time on self-reporting and help MSK achieve greater engagement with required surveys.

But before that...

Projects: Christie's summer at MSK

christie_v1

Interaction with multiple projects and project roles

Digital Therapeutics

- Starts with **research** (both medical **papers** and patient **interviews**) on the design of VR trials — what VR to display, at what situations, for which demographics, etc.
- Involves experimentation with Unity or other animation **software** & VR **hardware** to create **prototypes**
- Requires careful planning of **patient trials** and a step-by-step guide to how a study may run in the future

Research | Prototype | Front-end
Back-end | Database | Trialing

Failure Knowledge Base

- Begins with **research** via **interviews** with the team on past project failure and lessons we wish to propagate
- Requires extensive reworking of **front-end design**, after which we can create a **back-end infrastructure** to securely store data
- Since we cannot yet populate such a database, we will likely have to run trial runs with other teams or test in **beta stage** before reframing

Research | Prototype | Front-end
Back-end | Database | Trialing

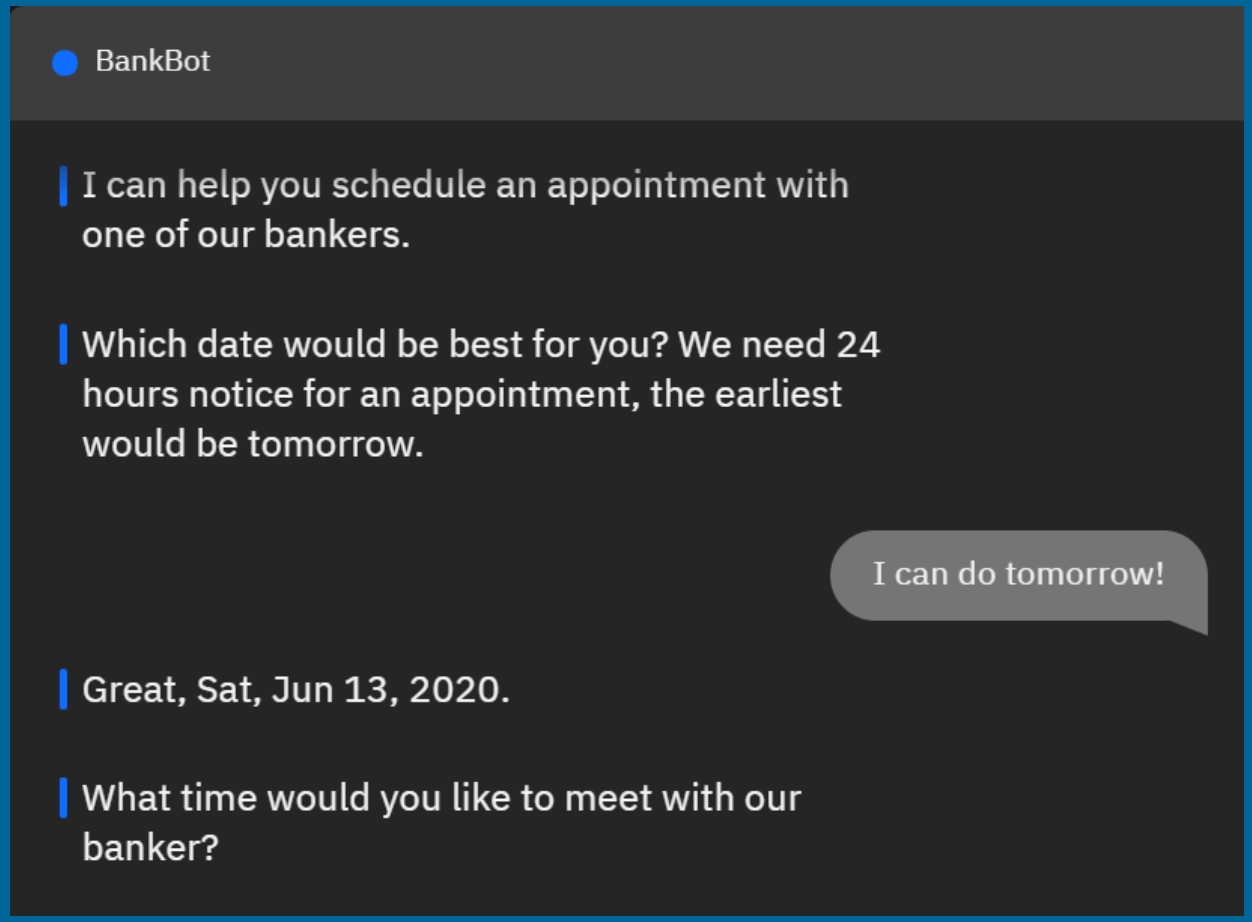
Ambient Computing

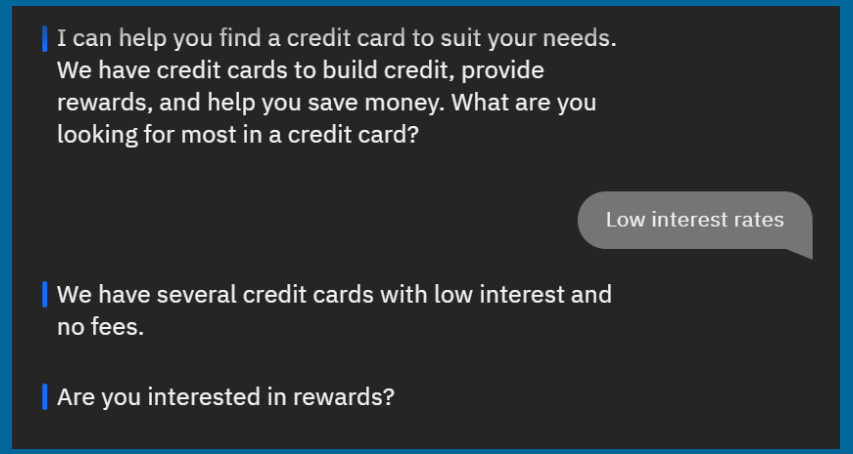
- Requires further **research** of SOTA as to what a digital transformation in clinical setting looks like
- Would require hardware work as well as **back-end** engineering, **hardware design**, and lots of **QA testing**
- Most importantly, since ambient computing is all about seamlessness with the everyday, such a project would require extensive patient-physician **trialing and surveying**

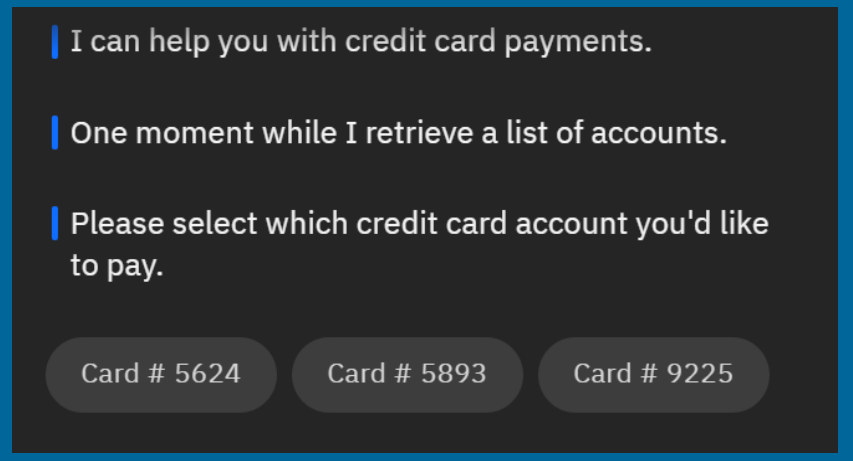
Research | Prototype | Front-end
Back-end | Database | Trialing

christie_v2

Conversational Interface







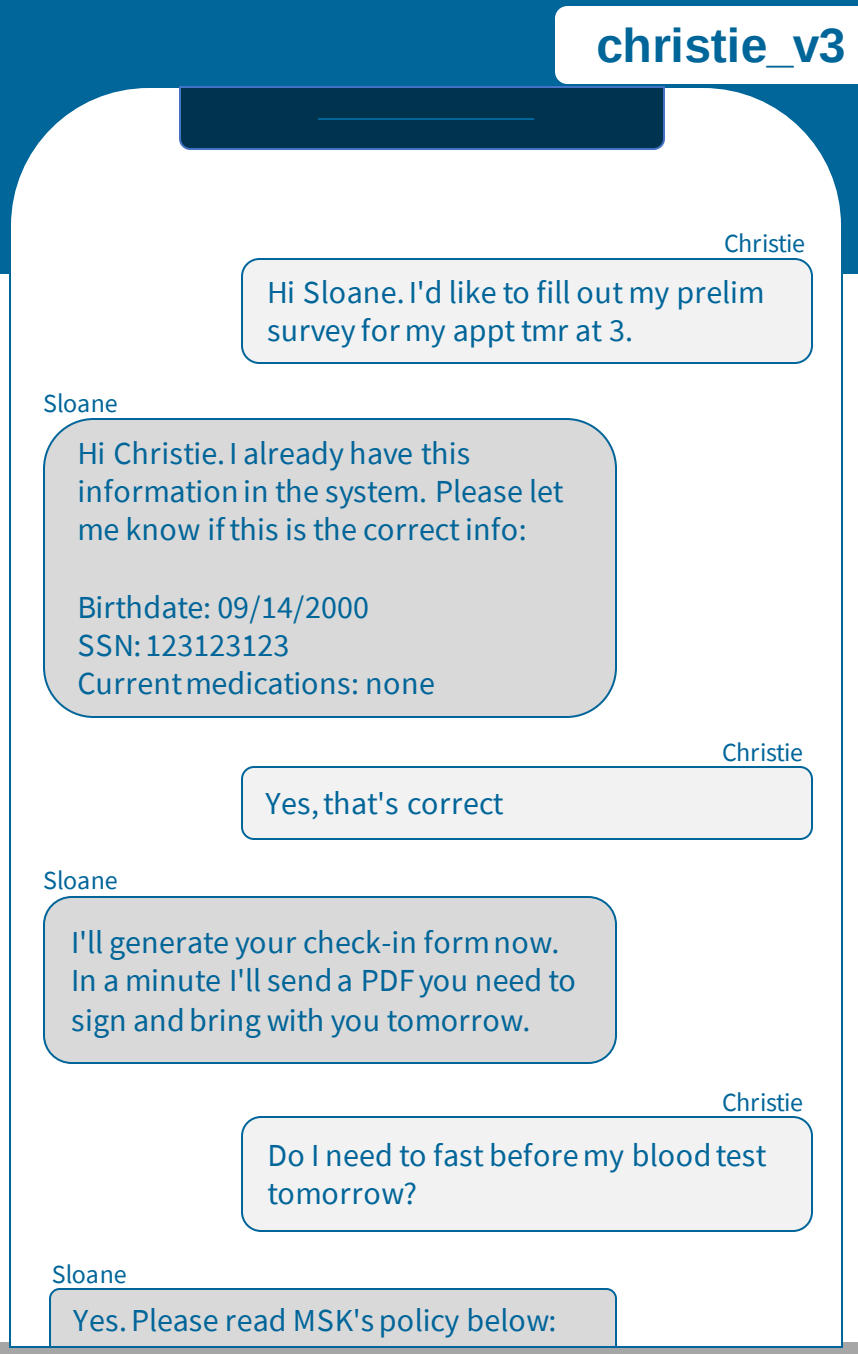
Conversational Interface: Project

Digital transformation of the patient/physician experience

Developing a beginning-to-end appointment aid

Mission: create a "personal assistant" for patients from pre-visit to post-treatment

- **Appointment**: scheduling, what to bring, notifications
- **Forms***: auto-generate via natural language, jargon explanation
- **Treatment**: prescriptions, follow-up visits, reminders & warnings
- **Payment**: insurance breakdown, total payment transparency
- **Queries***: pulls information from database and only contacts physician if necessary
- **Notifications**: medication adherence reminders, fitness tracker
- Room for multilingual support, phone call version



Conversational Interface: Deliverables

christie_v3

Digital transformation of the patient/physician experience

Developing a beginning-to-end appointment aid

Appointment*

- **Prototype**: simulation of appointment scheduling
- **Implementation**: integration between IBM Watson and existing MSK scheduling software

Forms*

- **Prototype**: simulation of natural language form generation
- **Implementation**: transforming forms to natural language & secure PDF downloading

Payment

- **Prototype**: simulation of patient payment and record generation
- **Implementation**: integration between IBM Watson and existing MSK payment software

Treatment

- **Prototype**: design friendly reminder language; physician interface for inputting reminders
- **Implementation**: translating physician orders to Watson tasks

Queries*

- **Prototype**: Q&A simulation with chatbot redirection to general, MSK, patient-specific resources
- **Implementation**: training & testing IBM Watson ML capabilities

Notifications

- **Prototype**: patient & doctor request for notifications; design friendly reminder language
- **Implementation**: connecting chatbot app to individual devices

Conversational Interface: Deliverables

christie_v4

Digital transformation of the patient/physician experience

Developing a beginning-to-end appointment aid

Forms

- Create a **chatbot** that can:
  1. Identify **intent** when patients ask to fill out a specific type of form
  2. Depending on PHI security, be able to **pre-fill** the form with existing knowledge
  3. Ask user for info in a **natural**, comfortable way
  4. **Save info** for next form
  5. Generate secure **PDF's** for the user to sign
  6. [Conduct rudimentary **sentiment analysis** for patient experience forms (MSK Engage)]

Queries

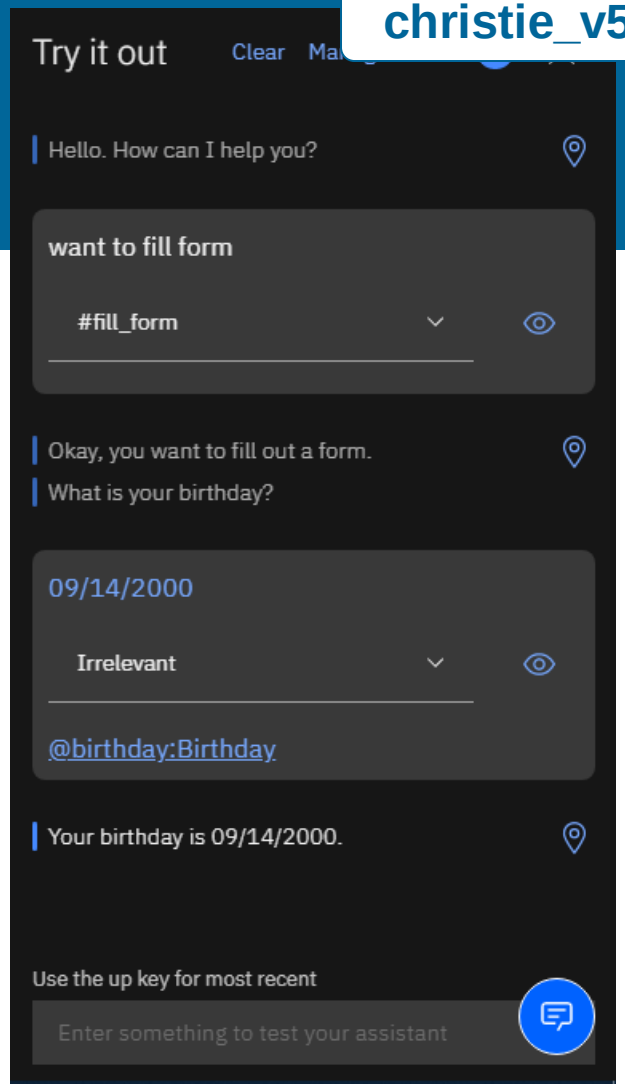
- Focus on **one dataset** primarily
  - e.g: MSK-specific q's from 1 knowledge base
  - or even more specific sector, like MSK's chemotherapy protocols, policies, and payments
- Create **chatbot** with concluding **report**
  - Detailed **precision & recall** measurements
  - **Training** & **testing** set counts
  - Major blockers and bot's areas of confusion
    - Bot comes pre-filled with sector knowledge

Conversational Interface: Engage integration

My first technical task is integrating IBM Watson with MSK Engage's database

Project pt 1: Integrate IBM Watson with MSK Engage

1. Retrieve MSK Engage Q&A text and display it as **IBM Watson Assistant chatbot** dialogue
2. Chatbot can **handle user mistakes**, interruption, nonsensical answers, etc
3. Chatbot **uses API's** to retrieve **PHI** as proof of concept that chatbot can smartly pre-populate known answers (e.g: medication history)
4. Chatbot inserts responses to existing **MSK Engage database**
5. Chatbot **returns different instructions** based on user input (e.g: recommendation to call PHP)



This week I worked on understanding Watson interface & having the assistant identify user intent & store user variables

Conversational Interface: Prototype

christie_v5

I will also prototype the features of an engaging CI app

Project pt 2: Prototype patient texting experience

- Consider the **full chatbot experience**
    - Design **alerts and reminders** for new forms to complete
    - Design **transition** between forms if users have multiple forms to fill
- **What can a chatbot provide that MSK Engage cannot?**
    - What will **maximize patient engagement** while **minimizing patient work**?
        - **Patient burnout** is real!
        - Leverage our existing attachment to mobile phones & create **easy texting experience**
            - Research the **best platform** for users to receive notifications & chat with bot (MSK app? Messenger? WhatsApp?)
            - **Deliverable**: visual prototype of interactions, functionalities, alerts, etc.

Exploring IBM Watson as a product to conversationalize surveys

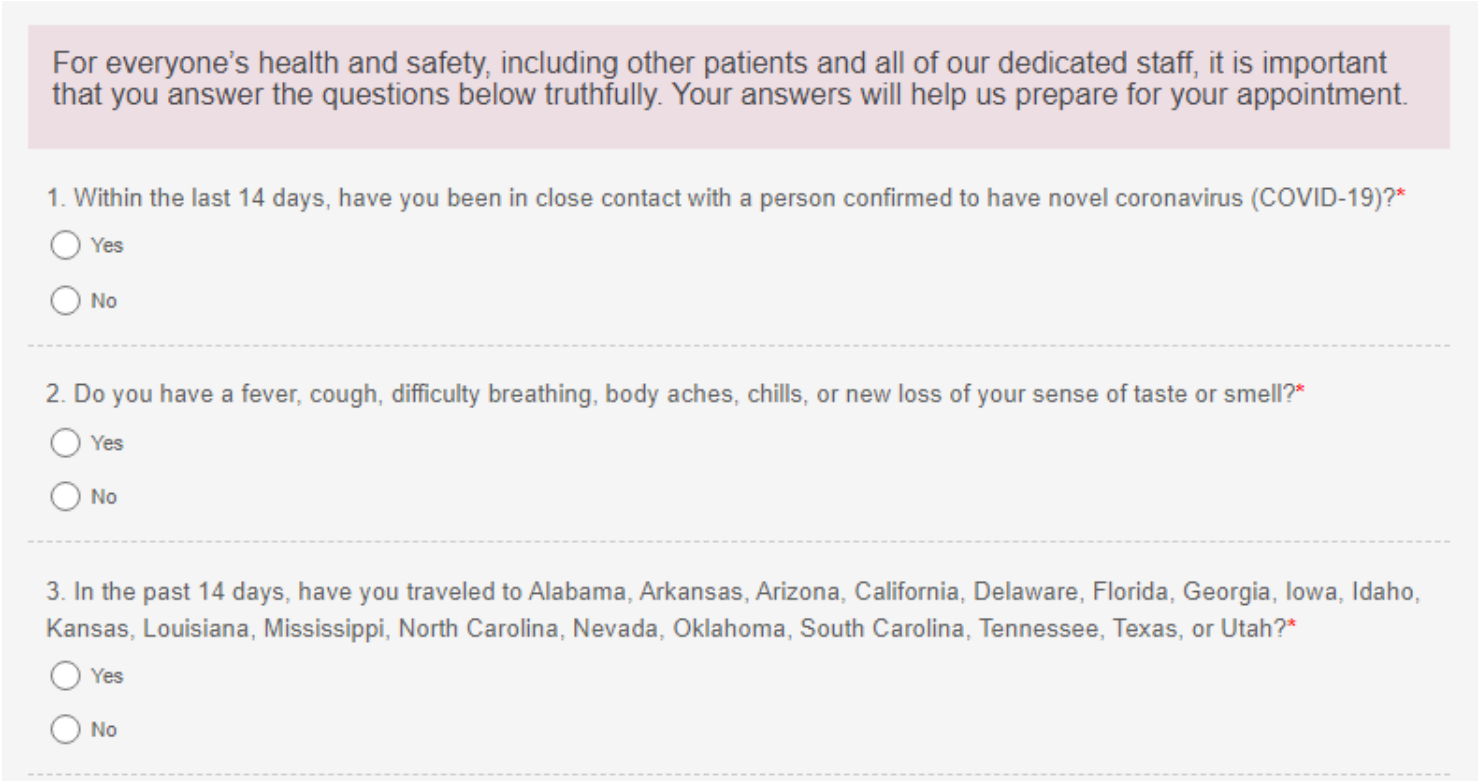
Integrating MSK Engage with an IBM Watson assistant

Conversational Interface: Example COVID form

christie_v5

To show a proof of concept, I will conversationalize the current COVID screening form

Proof of Concept: Novel Coronavirus (COVID-19) Screening Questionnaire



For everyone's health and safety, including other patients and all of our dedicated staff, it is important that you answer the questions below truthfully. Your answers will help us prepare for your appointment.

1. Within the last 14 days, have you been in close contact with a person confirmed to have novel coronavirus (COVID-19)?*

- ◯ Yes
- ◯ No

2. Do you have a fever, cough, difficulty breathing, body aches, chills, or new loss of your sense of taste or smell?*

- ◯ Yes
- ◯ No

3. In the past 14 days, have you traveled to Alabama, Arkansas, Arizona, California, Delaware, Florida, Georgia, Iowa, Idaho, Kansas, Louisiana, Mississippi, North Carolina, Nevada, Oklahoma, South Carolina, Tennessee, Texas, or Utah?*

- ◯ Yes
- ◯ No

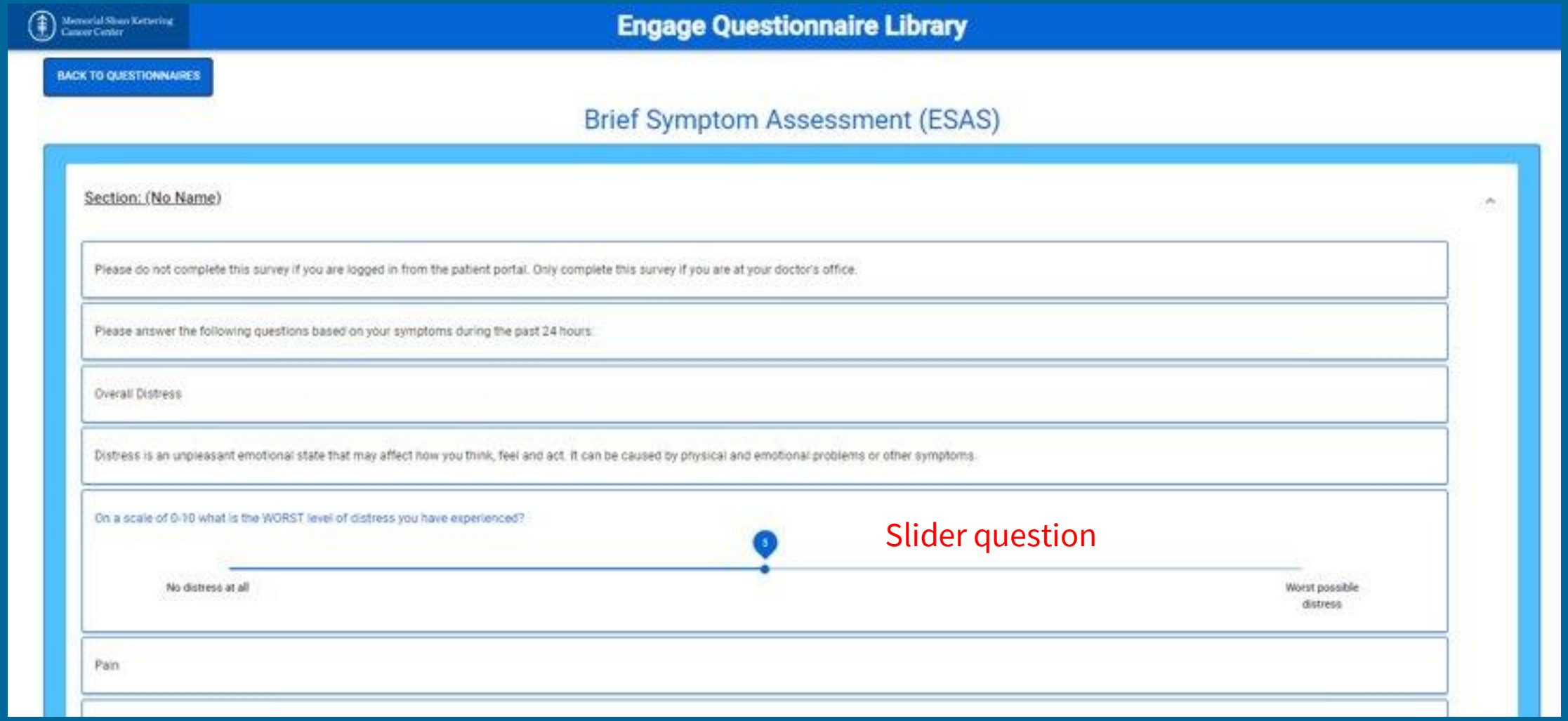
Ideal CI proof of concept candidate

- Widely used
- Short & sweet
- Little room for user error
- Returns customized user alert based on user COVID risk

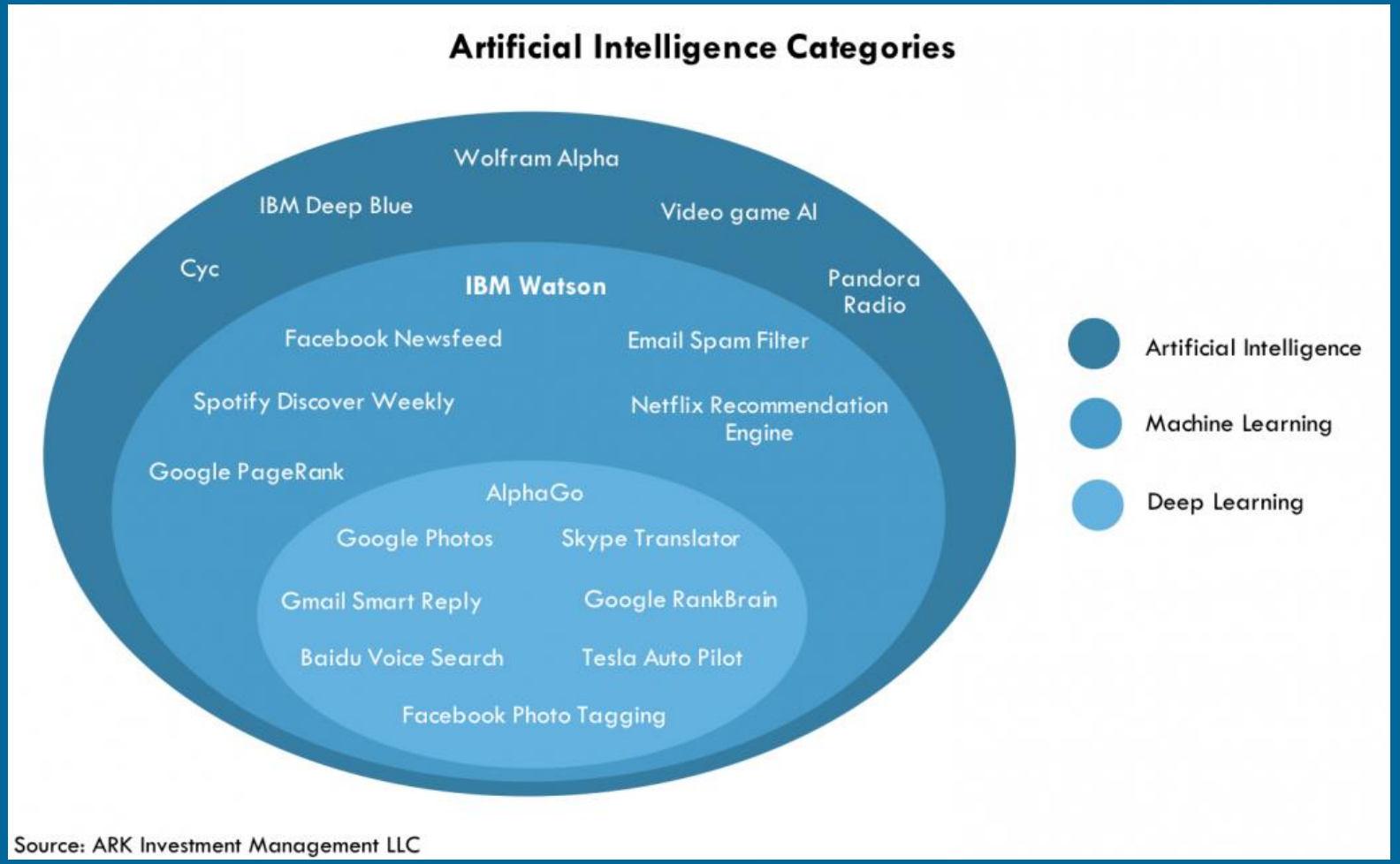
Ambitious future use case: CARE questionnaire

- Widely used
- 80 questions
- Heavy clinical language

Different types of questionnaires

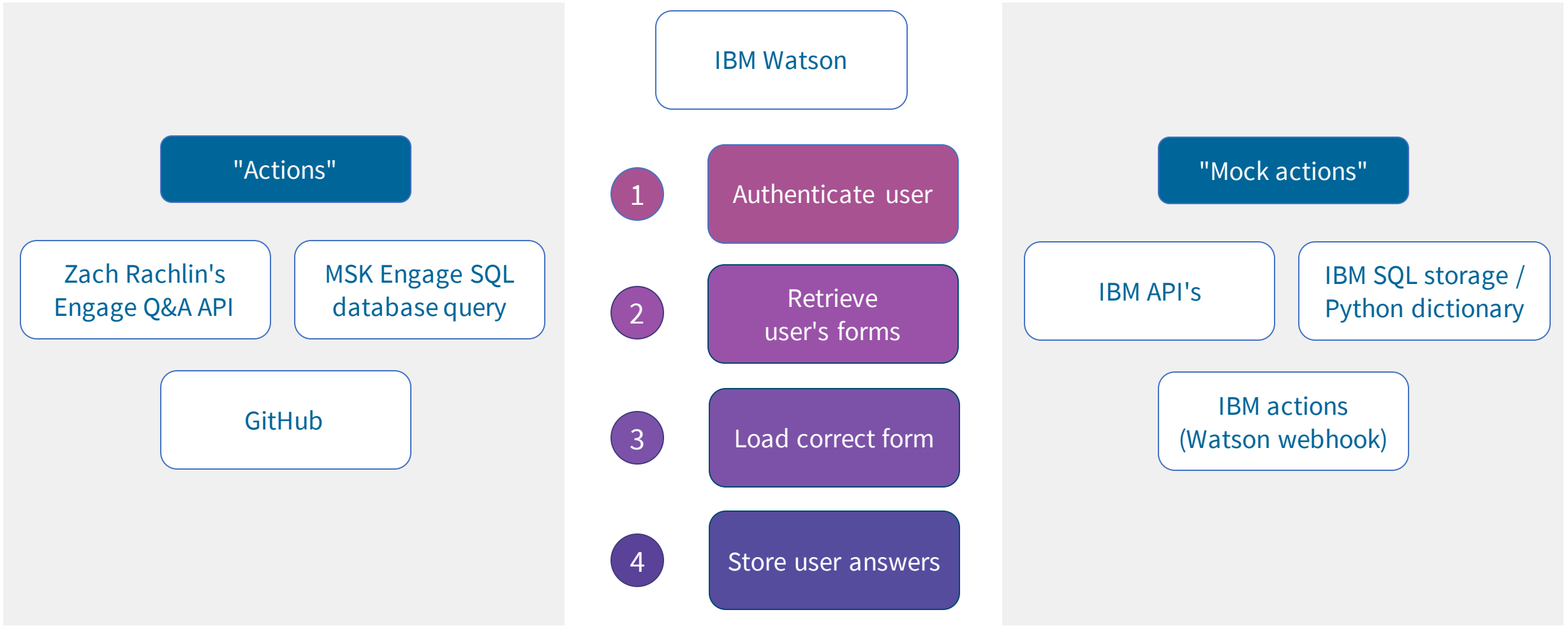


IBM Watson demo



IBM Watson: Infrastructure

Digital transformation of the patient/physician experience



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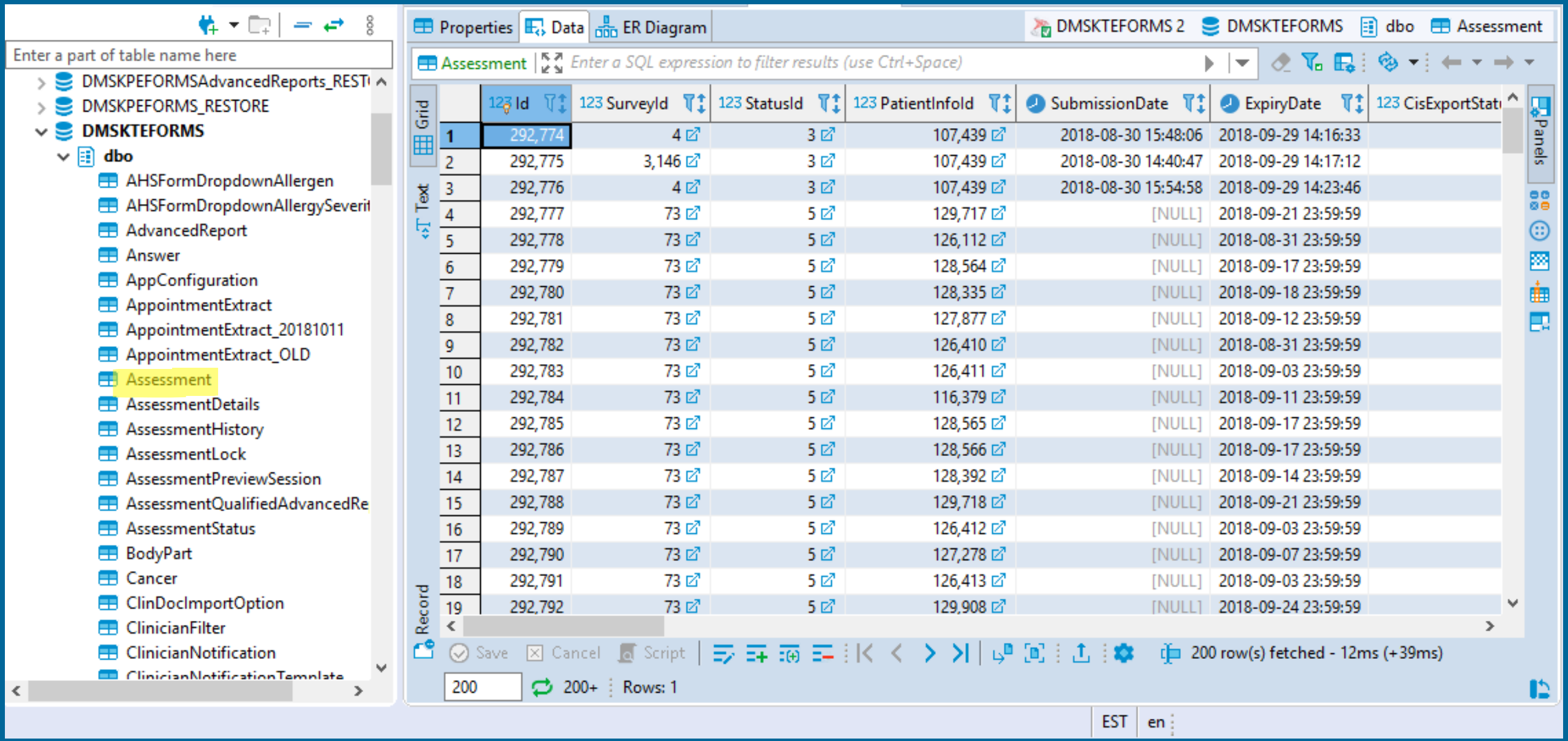
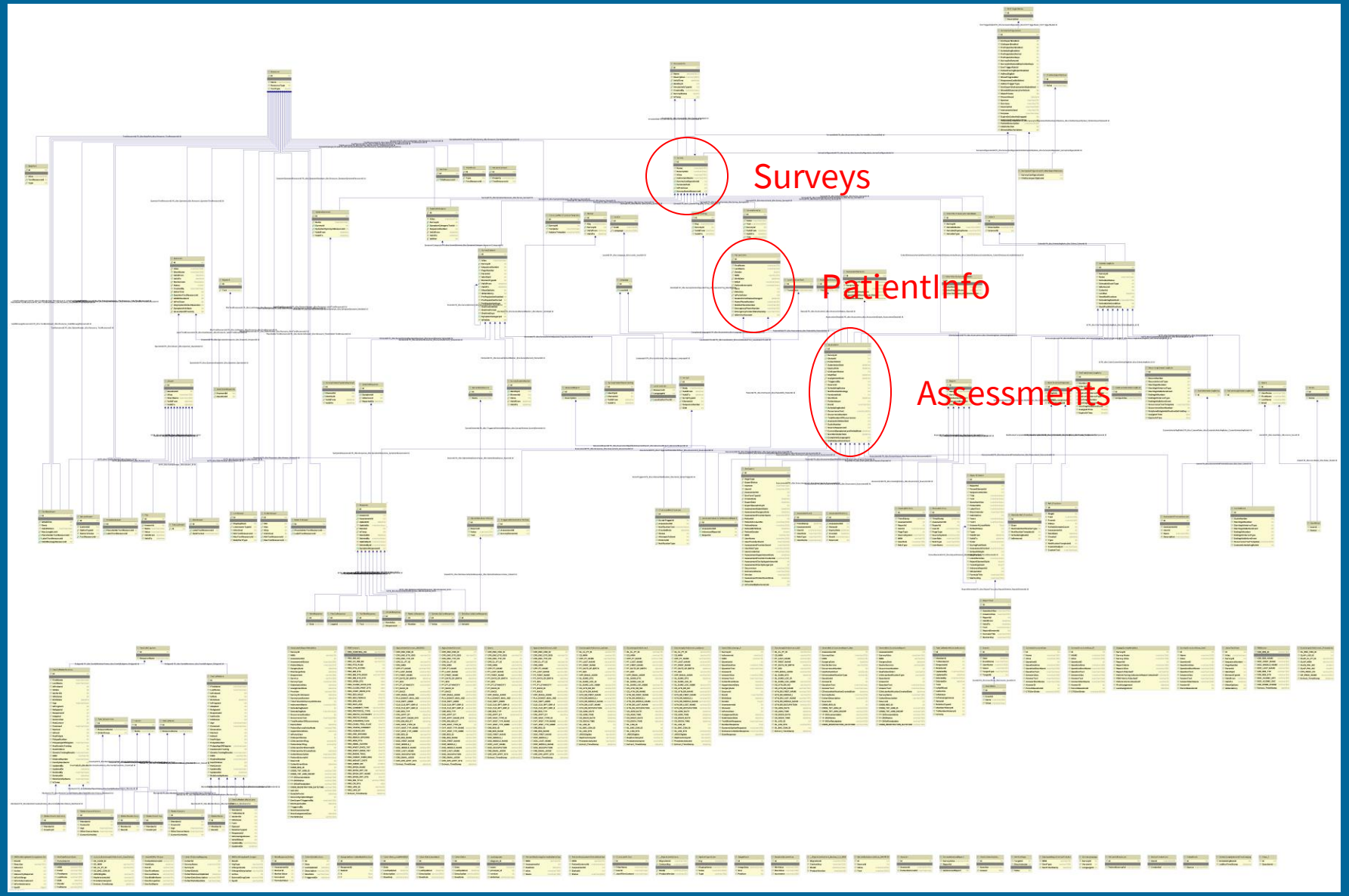
Pulling questionnaires from Zach Rachlin's API

Engage behind-the-scenes

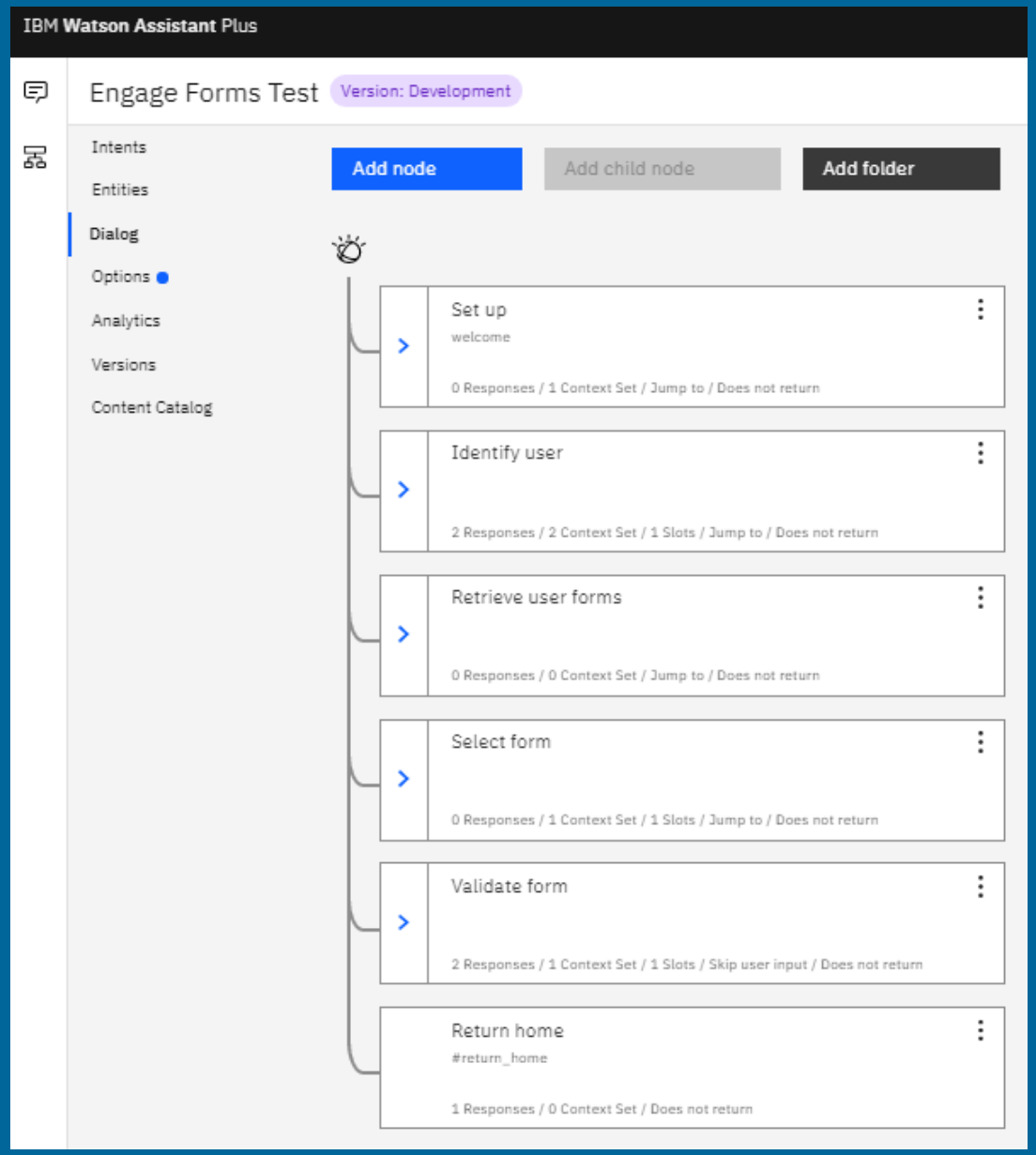


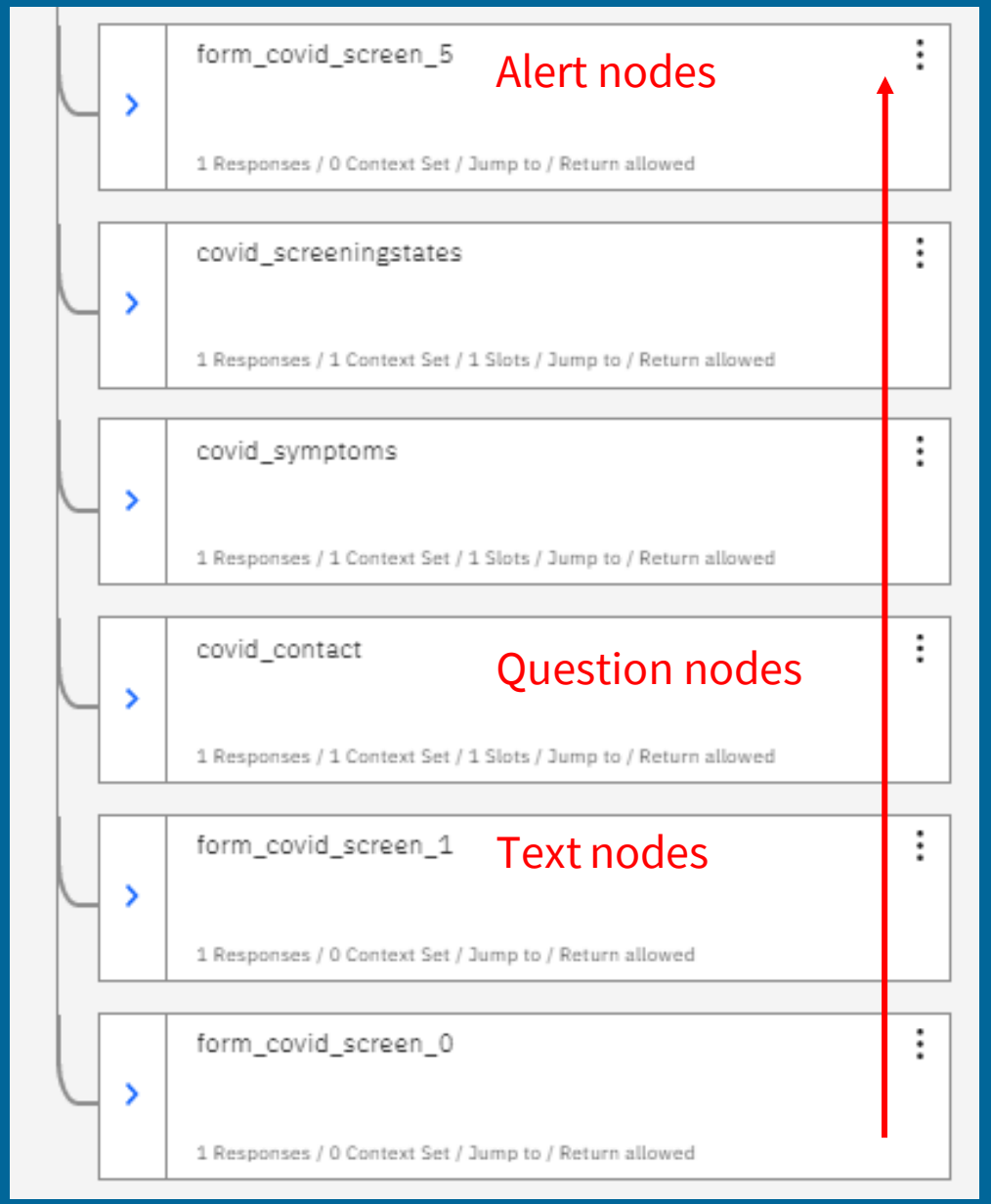
… Engage *behind* behind-the-scenes



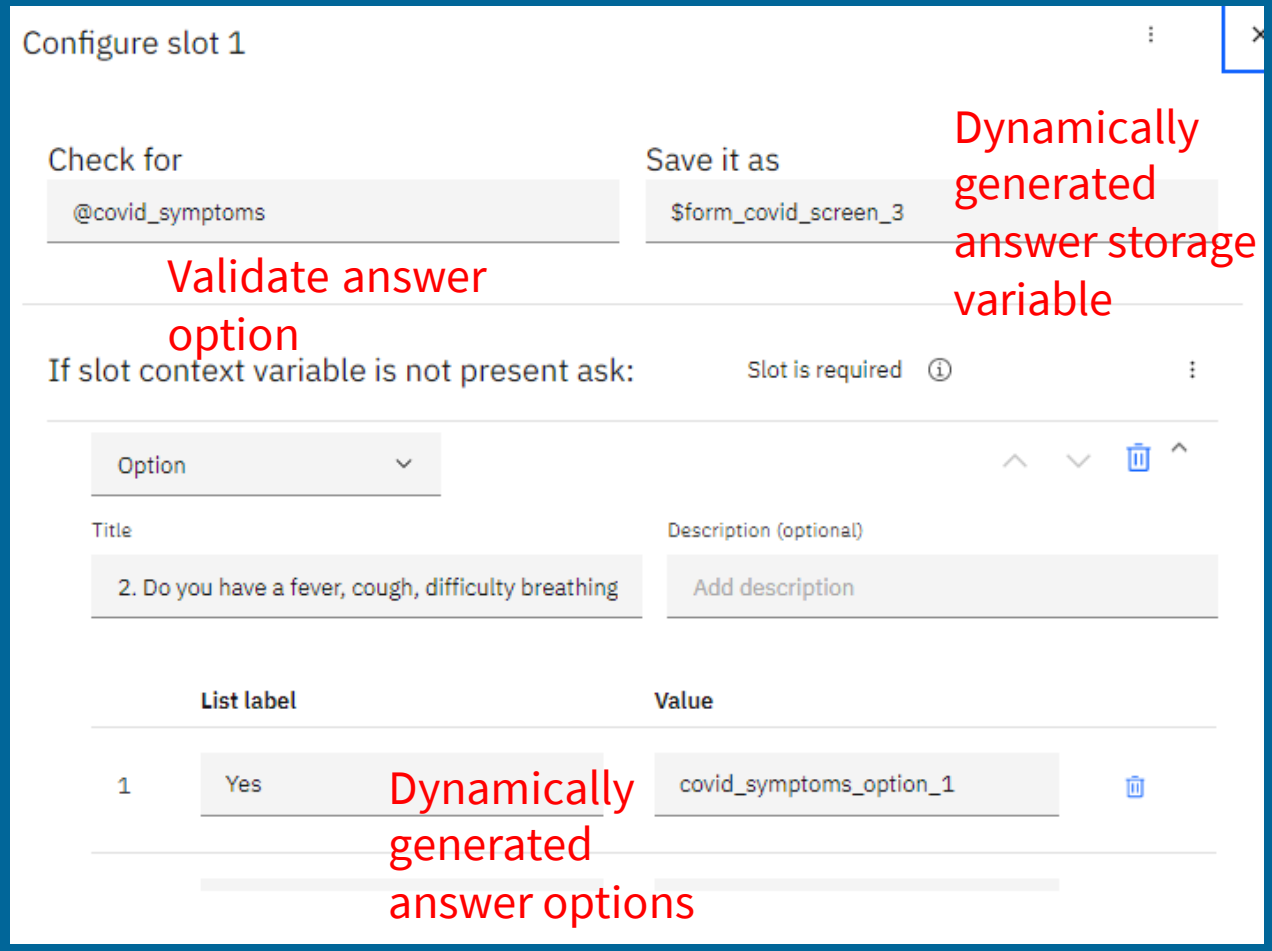
- ~1,500,000 assessments
- ~190,000 patients
- 147 tables in database
- Lots of ID systems…

Dialog nodes

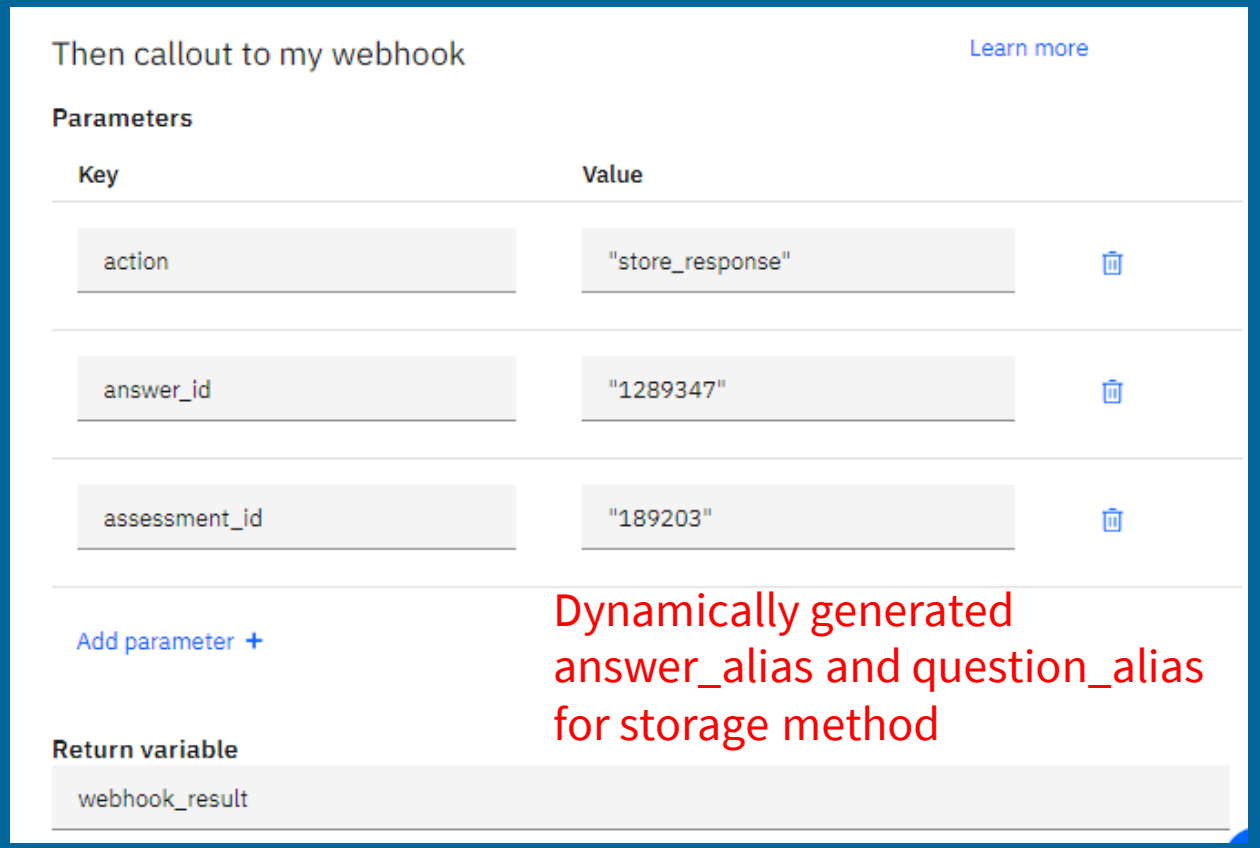




Slots



Webhooks



"Entities" for answer verification

Question alias

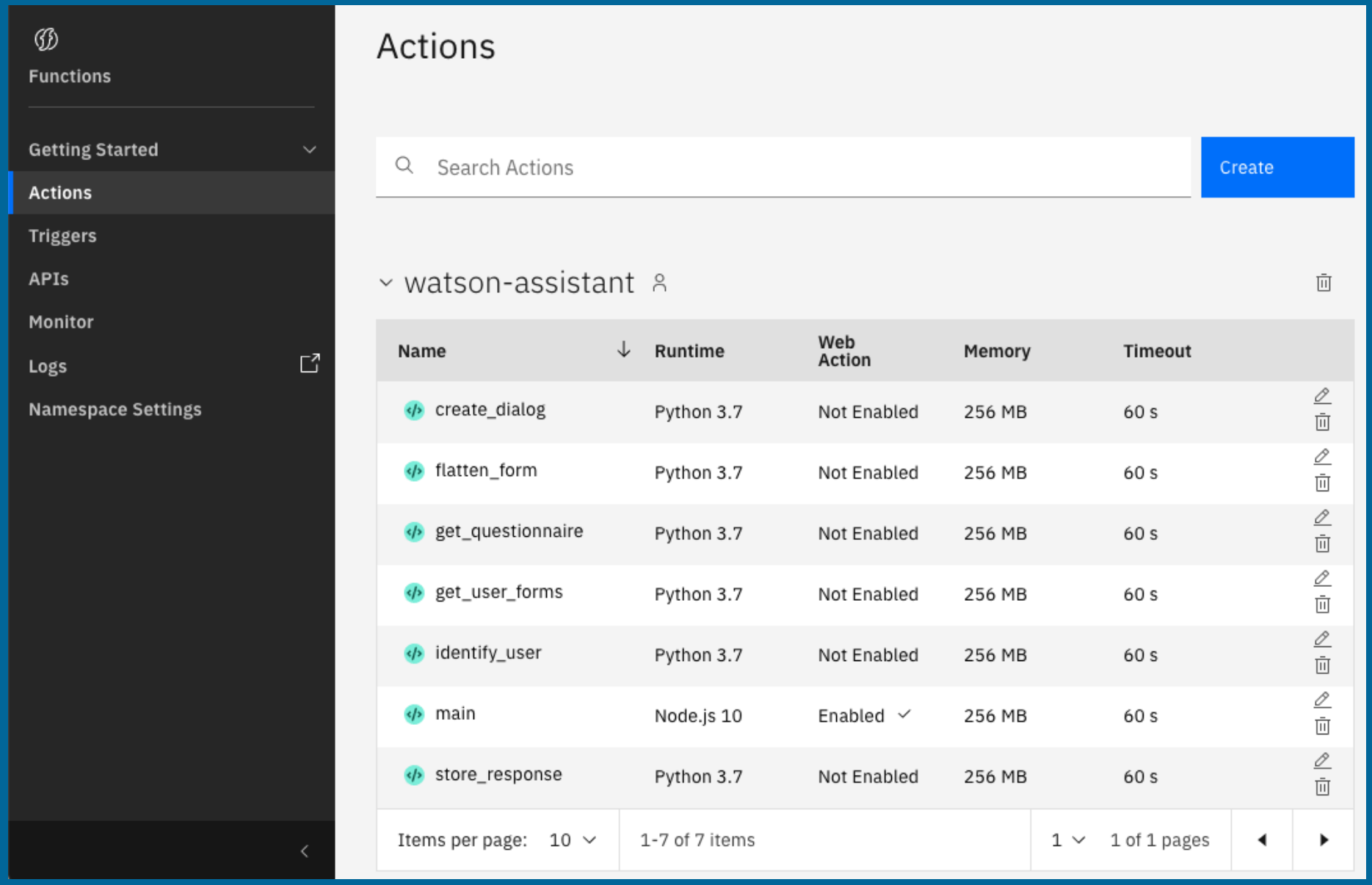
Possible "synonyms" = possible answer choices

Create entity +

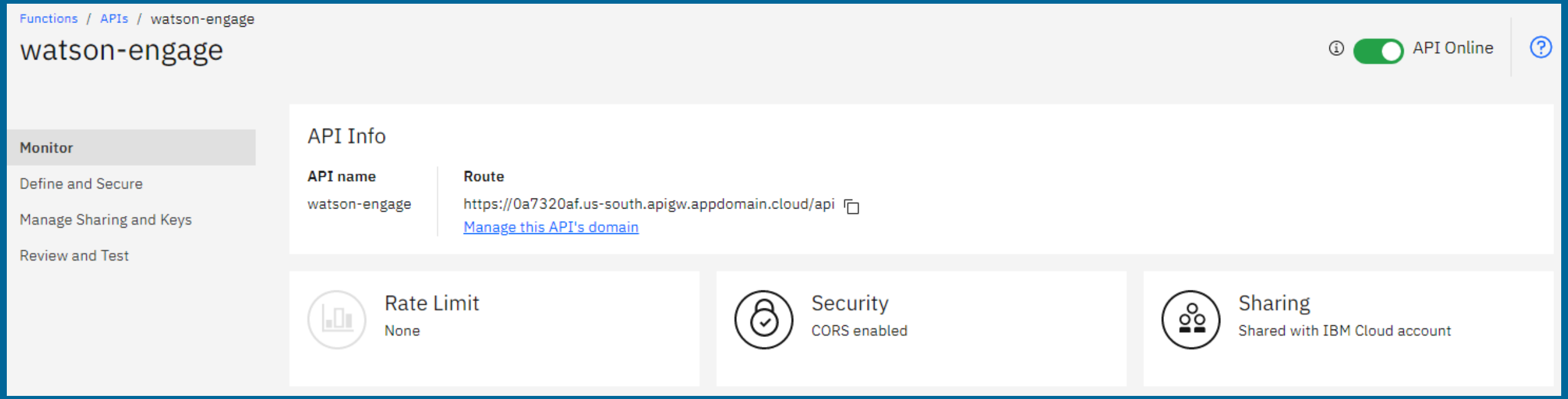
Entity (41)	Values	Modified
@bowelproblemsq	bowelproblemsq_bowelproblemsnone, bowelproblemsq_bowelproblemssmall, bowelproblemsq_bowelproblemsmod, bowelpr...	8 days ago
@brief_breathing	brief_breathing_option_0, brief_breathing_option_9, brief_breathing_option_8, brief_breathing_option_4, brief_breathing_opti...	8 days ago
@brief_constipation	brief_constipation_option_7, brief_constipation_option_10, brief_constipation_option_2, brief_constipation_option_4, brief_con...	8 days ago
@brief_depression	brief_depression_option_7, brief_depression_option_10, brief_depression_option_0, brief_depression_option_4, brief_depressi...	8 days ago
@brief_distress	brief_distress_option_3, brief_distress_option_4, brief_distress_option_5, brief_distress_option_7, brief_distress_option_8, brie...	8 days ago
@brief_fatigue	brief_fatigue_option_7, brief_fatigue_option_4, brief_fatigue_option_8, brief_fatigue_option_2, brief_fatigue_option_6, brief_fat...	8 days ago
@brief_nausea	brief_nausea_option_8, brief_nausea_option_2, brief_nausea_option_4, brief_nausea_option_7, brief_nausea_option_1, brief_...	8 days ago
@brief_pain	brief_pain_option_1, brief_pain_option_4, brief_pain_option_3, brief_pain_option_8, brief_pain_option_6, brief_pain_option_5,...	8 days ago
@brief_peace	brief_peace_option_3, brief_peace_option_4, brief_peace_option_5, brief_peace_option_8, brief_peace_option_7, brief_peace_...	8 days ago
@brief_sleep	brief_sleep_option_2, brief_sleep_option_10, brief_sleep_option_7, brief_sleep_option_3, brief_sleep_option_5, brief_sleep_op...	8 days ago
@brief_worry	brief_worry_option_5, brief_worry_option_9, brief_worry_option_8, brief_worry_option_2, brief_worry_option_6, brief_worry_op...	8 days ago
@Covid_contact	Covid_contact_option_0, Covid_contact_option_1	8 days ago
@covid_screeningstates	covid_screeningstates_option_0, covid_screeningstates_option_1	8 days ago
@covid_symptoms	covid_symptoms_option_0, covid_symptoms_option_1	8 days ago

Webhook-side

- Retrieves ser info
- Retrieves users' assessments
- Retrieves surveys
- Room for answer storage (currently Python dictionaries)

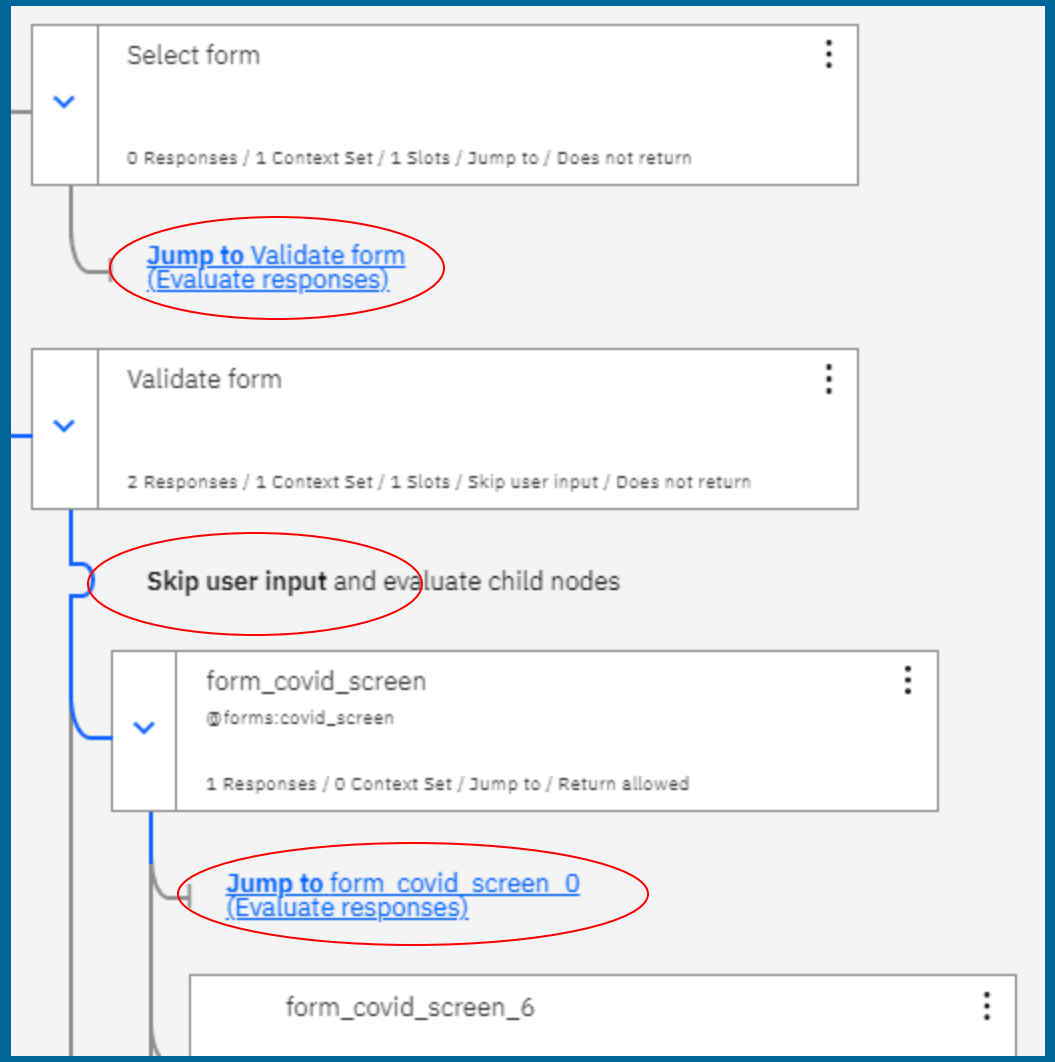


Also interacts with IBM API's

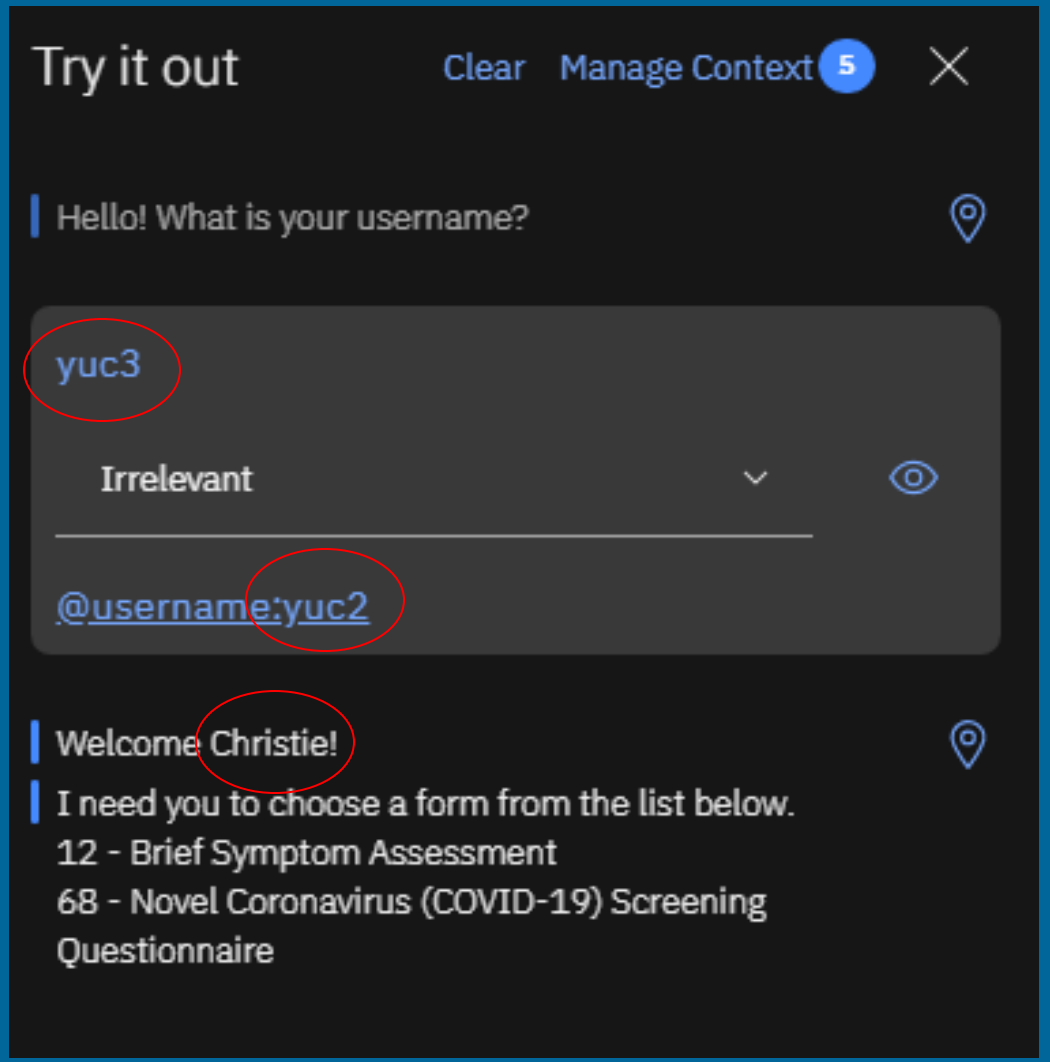


What Ricardo and I learned

Hard-code "jumps"



Entity recognition



IBM Watson: What Ricardo and I learned

A survey may not be a conversation

Lessons from this exploration

- IBM Watson is a powerful integrated platform with SQL storage, API's, function methods, chatbot AI, etc
- But... it is a little too powerful for a transactional task like survey-filling ("on rails")
    - Not taking advantage of IBM's cognitive capability; technology mismatch

A survey may not be a conversation, but the survey experience is!

- Lots of creative ways to:
    - Transition between surveys
    - Remind users to complete forms
    - Assess non-verbal cues
- **How do we make MSK Engage "friendly"? Now *that* is a conversational task!**

Conversational Interface: Project

Digital transformation of the patient at MSK experience

Developing a beginning-to-end appointment aid

Mission: create a "personal assistant" for patients from pre-visit to post-treatment

- **Appointment**: scheduling, what to bring, notifications
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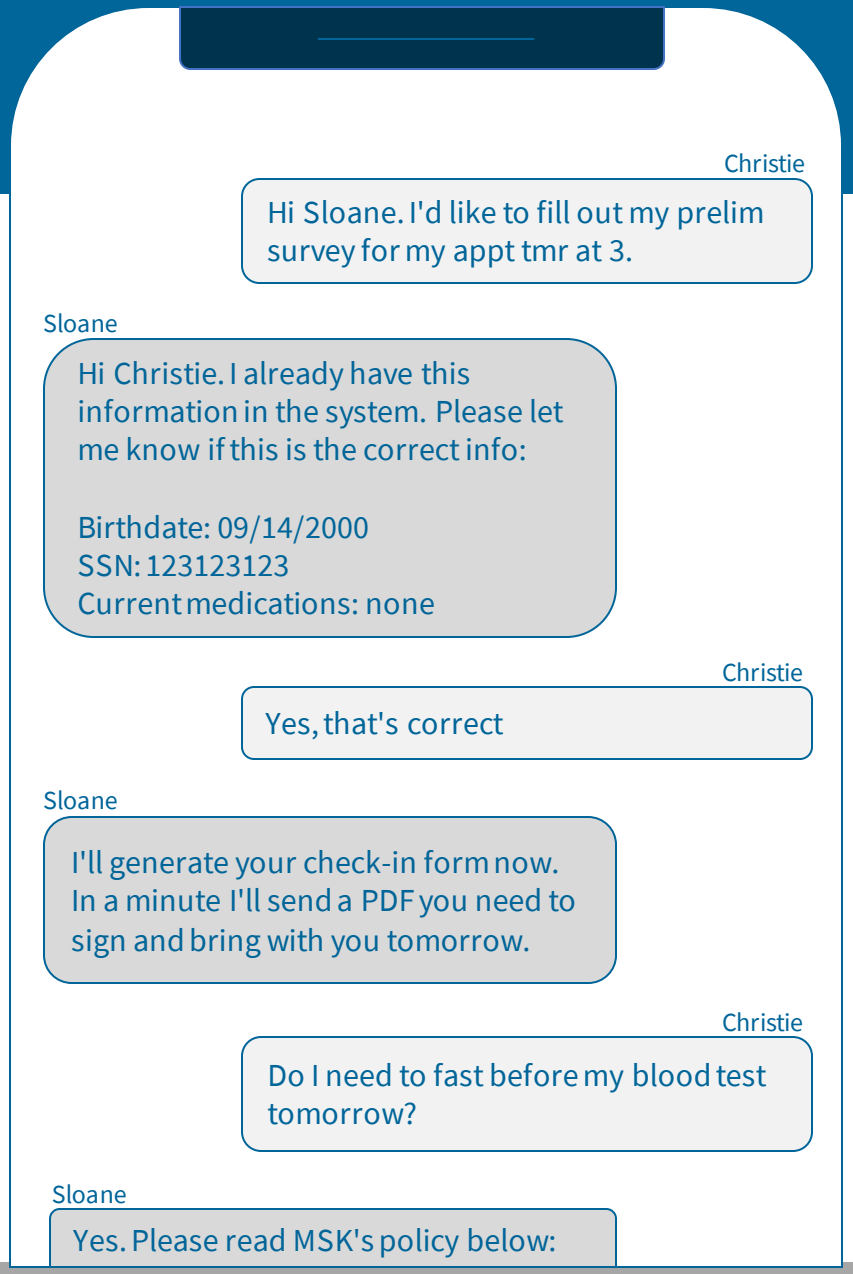


Conversational Interface: Digital transformation

Digital transformation of the patient at MSK experience

Problems	Project solutions
Physician burnout	**Offloading physician work**: questions are filtered, only reaching physician if truly necessary; also reduces secretarial work & patient lookup process
Patients unsure what resources to turn to	**Central knowledge bank**: combine general, MSK, and patient-specific info by merging databases = reliable PA throughout treatment process
Tedious paperwork often filled incorrectly	**Efficiencies on patient end**: no redundant PHI input for forms; filling out forms via natural language eliminates jargon barrier
PHI passes through too many hands	**Increased PHI security**: questions are not passed around the pipeline — only internal software "reads" patient PHI within patient account
Loss of autonomy for non-English speakers	**Multilingual support** (out of project scope?): multilingual chatbot for step-by-step walkthrough of forms, payments, scheduling

IBM Watson: For the future

So, what's next?

More with Engage

Further exploring IBM Watson for Engage

- Transition between forms
- User notifications (chatbot platform exploration)
- Non-verbal cues
- Voice

Exploring other conversational methods

- Twilio for "on rails" surveys
- Integration between Twilio and IBM Watson transitions

More with IBM

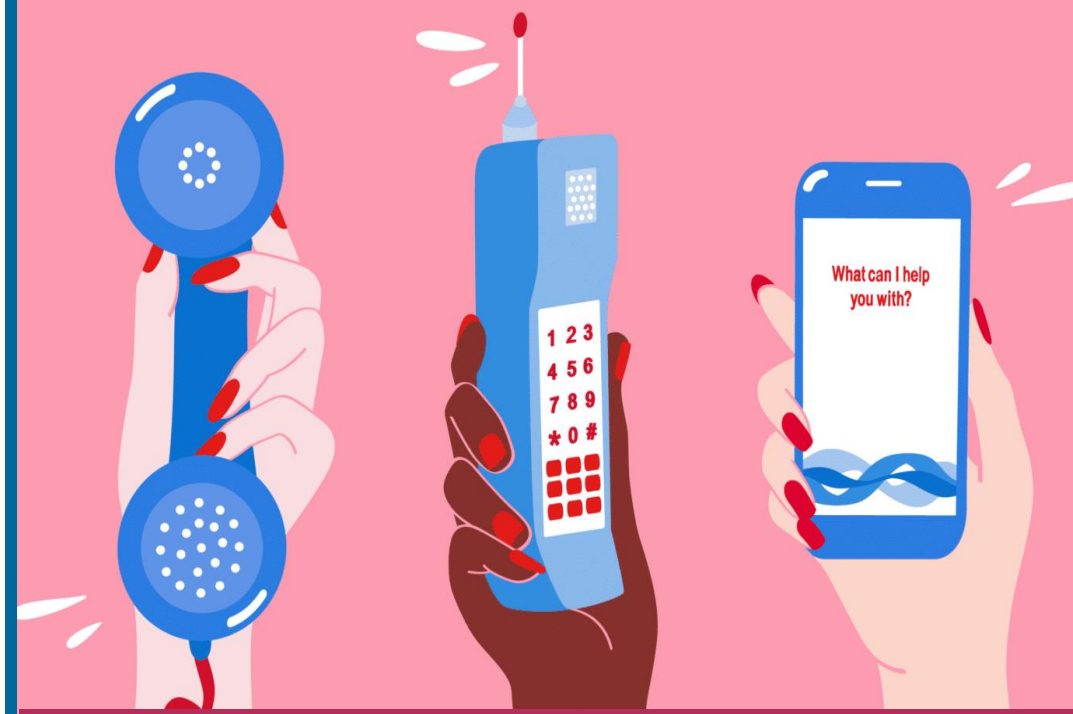
Further exploring IBM Watson as a platform

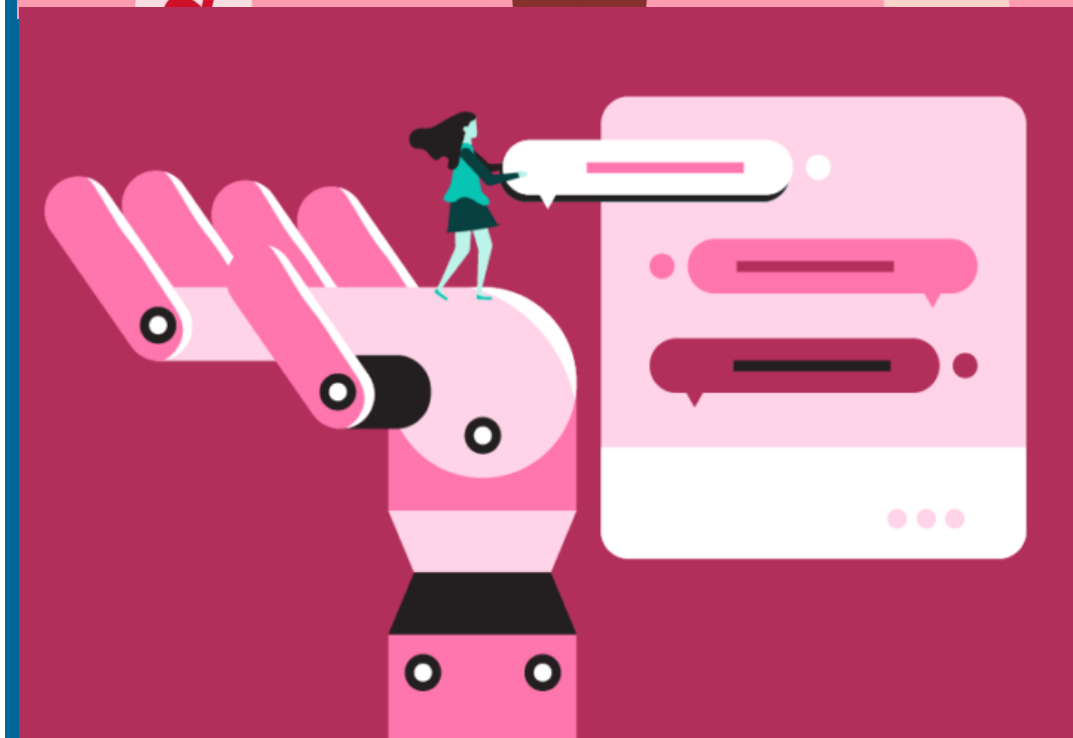
- Collaboration issues
- Security issues

Exploring IBM Watson for other uses

- Appointments
- Payments
- Queries
- Notifications

Turning **vision** into **action**





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Appendix

Appendix A: Conversational Interfaces

Conversational Interface: Background

Digital transformation of the patient/physician experience

Harnessing AI to reduce physician burnout

AI advancements can help reduce redundant work

- **General questions**
  - What are common side effects of Leukeran? Are they dangerous?
  - My doctor said I have low blood pressure. What does that mean?
  - I'm filling out a form. What does "medical record number" mean?
- **MSK questions**
  - Can I have visitors come in tomorrow at 5 p.m.?
  - Should I fast before tomorrow's surgery? Can I eat after my surgery?
  - Is this blood test covered by my insurance?
- **Patient-specific questions**
  - What were the results of my lab test? How long until they come back?
  - What immunizations do I have? Can I get a PDF of my history?
  - When is my next appointment?
  - Can I check my payment record?

For every **1** hour with a patient, physicians spend **2** at the computer.

More than **half** of physicians reported feeling burnt out.

Paperwork costs the health industry (conservatively) **$4.6 billion** annually.

Source

Conversational Interface: Cancer SOTA

Current advancements of chatbots in the cancer landscape

A Chatbot Versus Physicians to Provide Information for Patients With Breast Cancer

- "A total of 142 patients were included and randomized into two groups of 71. They were all female with a mean age of 42 years (SD 19). The success rates (as defined by a score >3) was **69% (49/71) in the chatbot group** versus 64% (46/71) in the physicians group. The binomial test showed the **noninferiority** (P<.001) of the chatbot's answers."
- Conclusion: "Artificial conversational agents may save patients with minor health concerns from a visit to the doctor. This could **allow clinicians to spend more time to treat patients** who need a consultation the most."
    - ➢ **Chatbots can accurately relay information and reduce physician burnout**

One-Year Prospective Study of Conversations Between Patients With Breast Cancer and a Chatbot

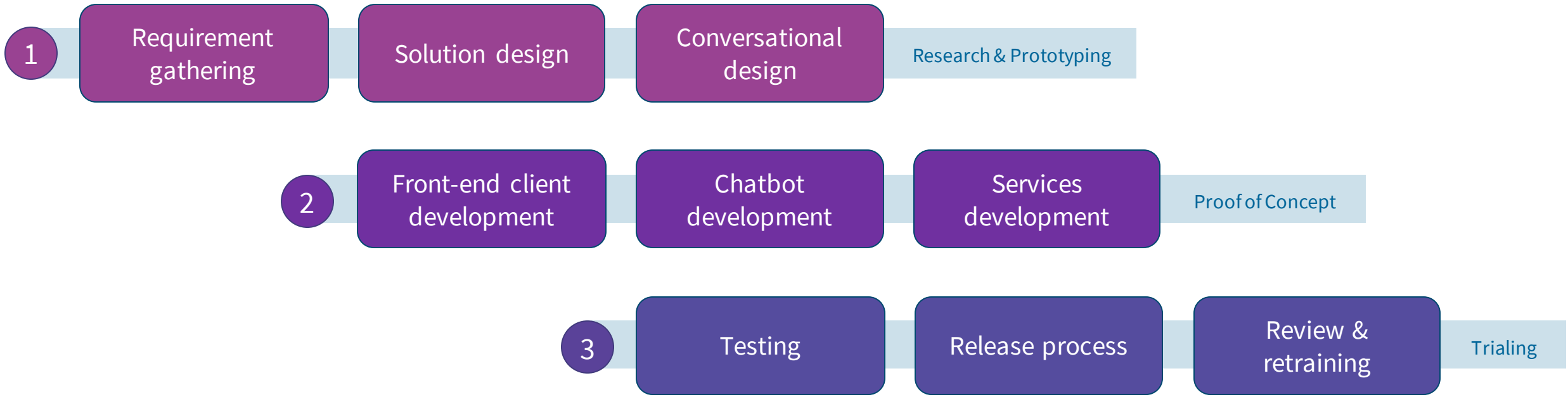
- "A total of 4737 patients were included. Results showed that an average of 132,970 messages exchanged per month was observed between patients and the chatbot, Vik … Patients regularly left **positive comments** and **recommended** Vik to their friends. The **overall satisfaction was 93.95%** (900/958). When asked what Vik meant to them and what Vik brought them, 88.00% (943/958) said that Vik **provided them with support** and helped them **track their treatment** effectively.
- Conclusion: "It is possible to obtain **support** through a chatbot since Vik improved the **medication adherence rate** of patients with breast cancer."
    - ➢ **Chatbots are effective at improving patient medication adherence and supporting patients emotionally**

Source

Conversational Interface: Timeline

Digital transformation of the patient/physician experience

Developing a beginning-to-end appointment aid

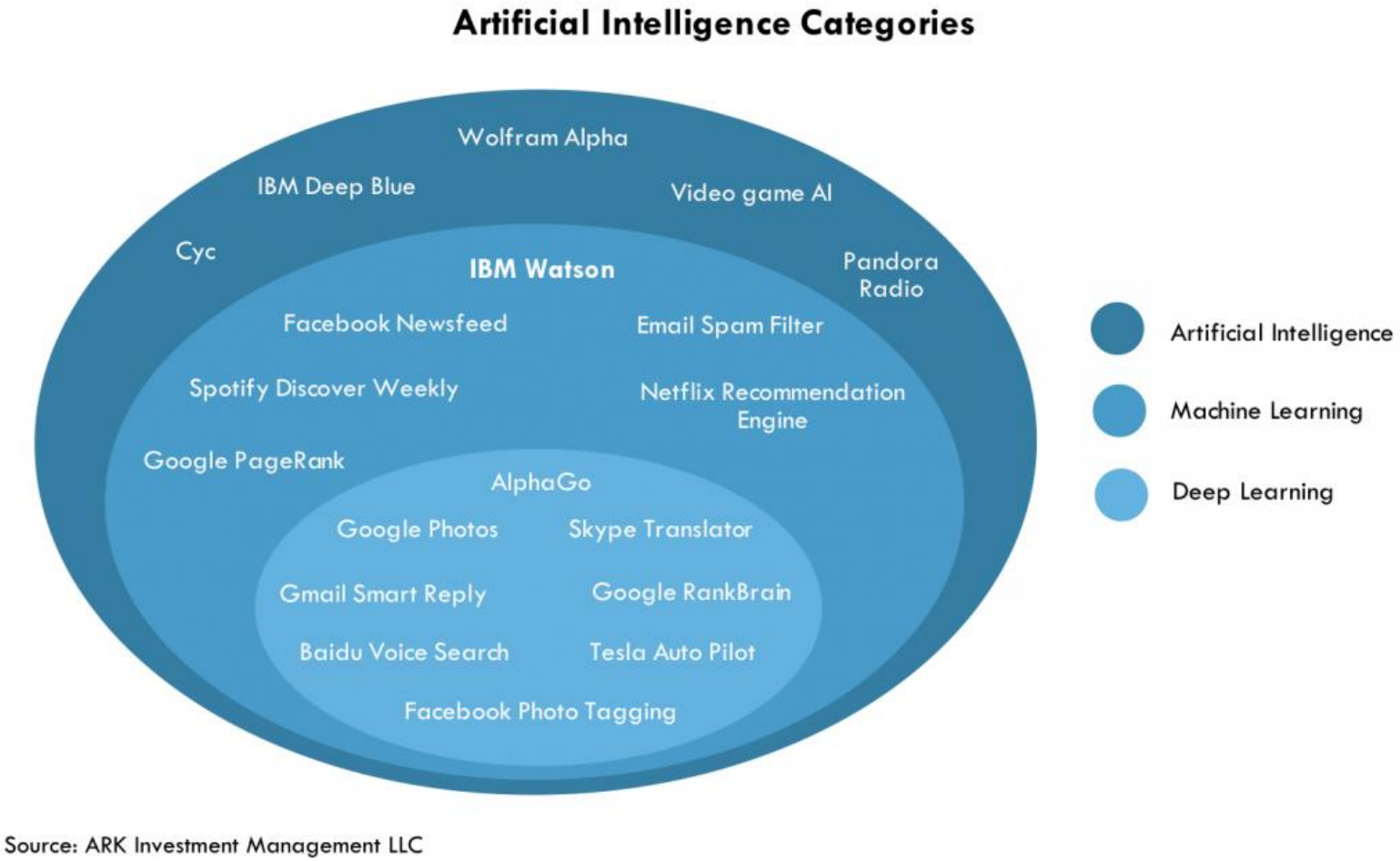


Source

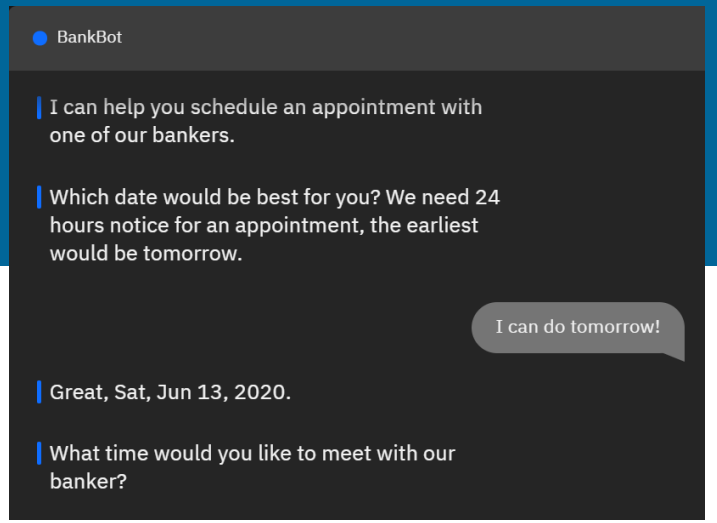
Appendix B: IBM Watson

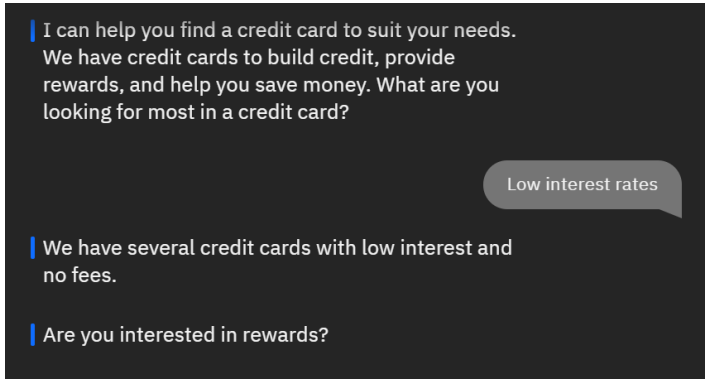
Conversational Interface: IBM Watson

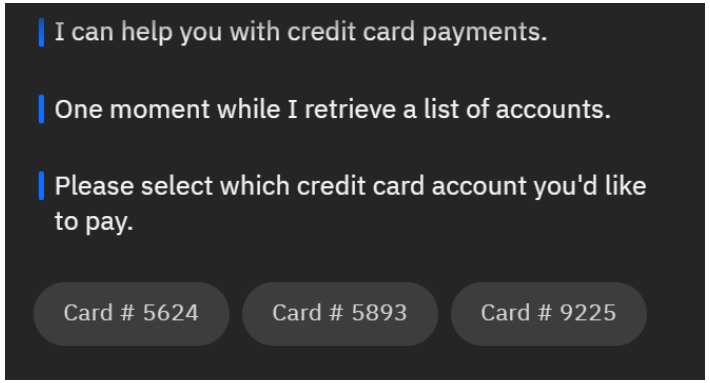
Digital transformation of the patient/physician experience



Source: ARK Investment Management LLC







Conversational Interface: IBM Watson

Digital transformation of the patient/physician experience

- IBM Watson **Assistant**
  - Build, test, and deploy a bot or virtual agent across mobile devices, messaging platforms, or even on a physical robot
- IBM Watson **Discovery**
  - A cognitive search and content analytics engine for applications to identify patterns, trends, and actionable insights
- IBM Watson **Natural Language Understanding**
  - Analyze text to extract meta-data from content such as concepts, entities, keywords, categories, sentiment, emotion, relations, and semantic roles, using natural language understanding
- IBM Watson **Tone Analyzer**
  - Uses linguistic analysis to detect communication tones in written text
- **Node.js**
  - An asynchronous event driven JavaScript runtime, designed to build scalable applications

Source

Conversational Interface: IBM Watson Assistant

Digital transformation of the patient/physician experience

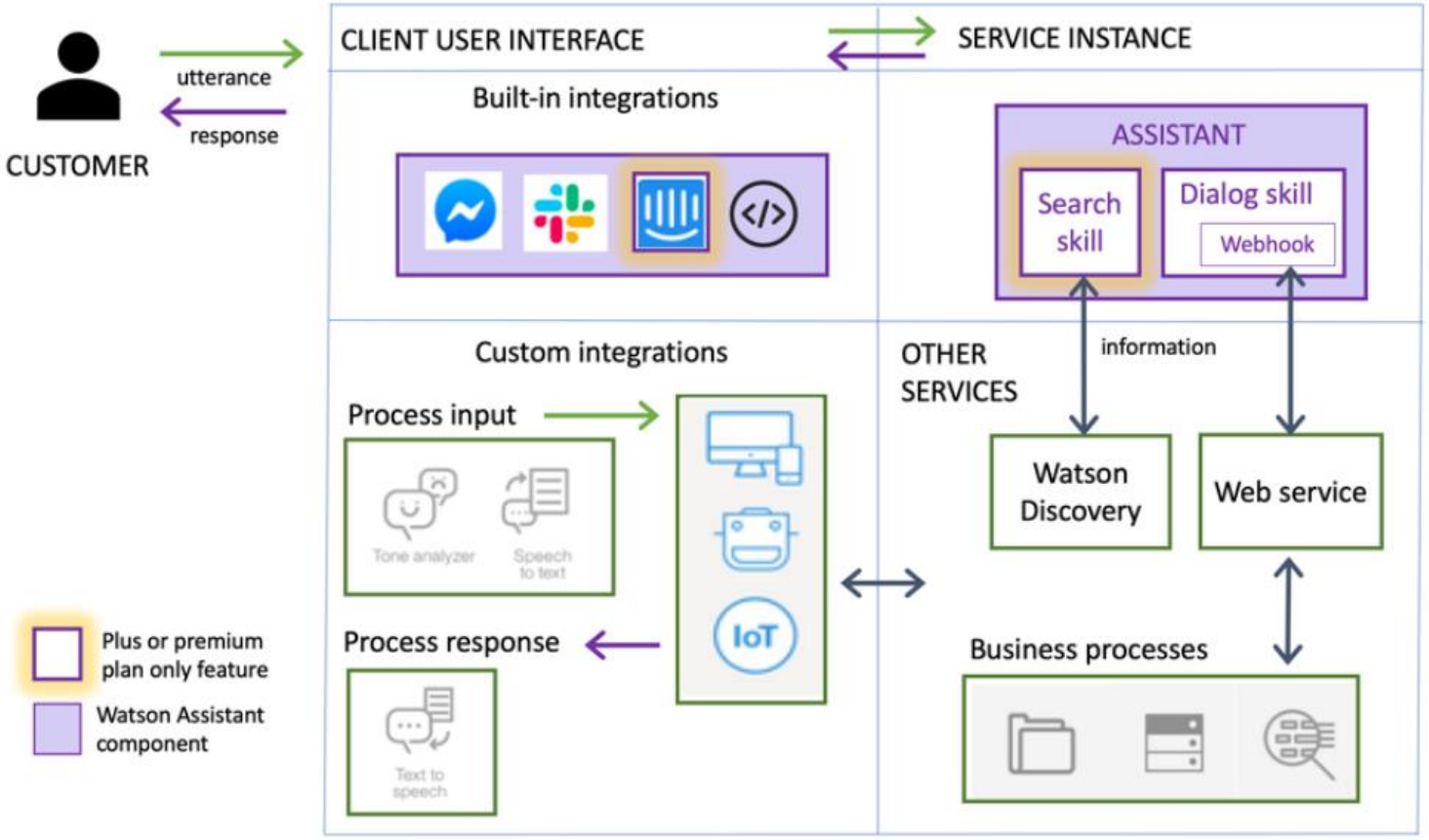


Figure 2: A typical approach used when deploying Watson Assistant

Source

- **Intents**
- **Entities**
  - System entities
- **Dialogues**
  - Condition
  - Response
  - Slots

Appendix B: Project Timeline

Conversational Interface: Updates

Forging a reliable, all-in-one assistant for MSK patients

Since we last spoke...

- I decided to **drop the knowledge base querying feature**. Wynne Kim (owner of the new knowledge bank) met with TechInc and it was clear that this project is still in ideation. I want to continue to sit in on these meetings so I can be better informed of the larger picture of CI, but I think I can't help much with knowledge base querying if 1) content isn't yet in the knowledge base and 2) the TechInc engineers are struggling to figure out where to start.
- I refined my forms idea. I spoke with Monica Allison (owner of MSK Engage) and she suggested I tackle the **3-question COVID screening form** as a proof of concept for **integrating IBM Watson with the MSK Engage SQL database**.
    - This involves integrating a bunch of API's and SQL queries. Priti Parekh, an engineer on Monica's team, suggested I retrieve Q&A text from an API rather than hard-code it, so the project can be **scalable** in the future for 80+ question surveys.
- I also plan on producing a **visual prototype** of what the forms chatbot experience will look like, from morning notifications to filling out multiple forms to alerting users to take further action depending on form response.

Conversational Interface: Steps taken

Here is who I've talked to so far.

General

- **Monica Allison** (MSK Engage owner) gave me points of contact on her team & access to Engage dashboard & test platform
    - **Alysse Kassa & Elizabeth Kemeny** (Monica's team) will give me an in-depth tour of MSK Engage interface
- **Wynne Kim** (new knowledge bank owner) outlined future collaboration timeline between TechInc and Fernanda's team... I decided here that I would not pursue engineering knowledge bank querying since TechInc engineering team (**Eric Schmitz & Mac Macgari**) themselves were struggling with progress on that

Engineering

- **Priti Parekh** (IS on MSK Engage API) gave me access to MSK Engage SQL database & info on next steps
- Reached out to **Bing Zhang & Peter Roehrich** (IS) for access to PHI API (they use this for clinical check-ins; user inputs ID and zip code, tablet asks them to verify their name)
- Reached out to **Zach Rachlin** (Health Informatics) for access to MSK Engage Q&A API so I can retrieve Q&A text dynamically for Watson = future scalability for 80+ question forms!

UI/UX

- **Divya Gaitonde** meets biweekly with me to advise project timeline & give feedback on project details
- Working with **Qingyan Ma** and **Keri Martin**'s team to collect secondary research on future of conversational interfaces
- And of course, **Kristine** has helped me every step of the way!

Proposed Timeline

W6: Import COVID questionnaire from Q&A text API (by Zach Rachlin) & create Watson logic

- Account for user making mistakes in form
- Account for user taking a break
- Account for user interrupting form
- Have answers collectable and ID'd for SQL insertion

W7: Chatbot connects to PHI API (Bing Zhang & Peter Roehrich) to authenticate user and pre-populate form

- Chatbot can identify user's name using ID/zip code input (POC that chatbot can connect to PHI and potentially pre-populate form)

W8: Form responds differently based on user input

- Input logic for COVID-suspected patients
- Alert user & store flag in SQL
- Retrieve PHP phone number for flagged patients (Bing's API)
- Retrieve list of next forms for user to complete (Priti's API)

W9: Prototype full chatbot forms experience using InVision & Adobe Illustrator

- Design schedule for forms reminders
- Write language for daily alerts
- Create visual prototype for all stages of patient forms experience