



Creating
DuoFactory
*An Orchestration
Ecosystem with
Airflow*
Summit 2025

3.0



Belle Romea,
Software Engineer
@ Duolingo



Duolingo ✅
@duolingo

Remember to not miss any lessons today! It wouldn't be very nice if we had to lock up your family.

12:07 PM · 30 Mar 19 · Twitter Web Client

2,578 Retweets 5,869 Likes



FBI ✅ @FBI · 47m

Replying to @duolingo

We are working on tracking you down. It is not okay to kidnap families because someone didn't complete a lesson.



Duolingo is a popular, free language-learning app that uses a gamified, bite-sized lesson approach to teach reading, writing, listening, and speaking skills

Write this in English



¿Cuáles son tus libros favoritos?

park are good your What favorite
books to learn bedroom



our mission is to
develop the best
education in the
world and make it
universally
available





... but how do we do that?





AIRFLOW
SUMMIT

meet the
duolingo
curriculums



Courses

New courses



Chess



Math



Music

For English speakers



Spanish



French



German



Italian



Japanese



CONTINUE



AIRFLOW
SUMMIT



6



0



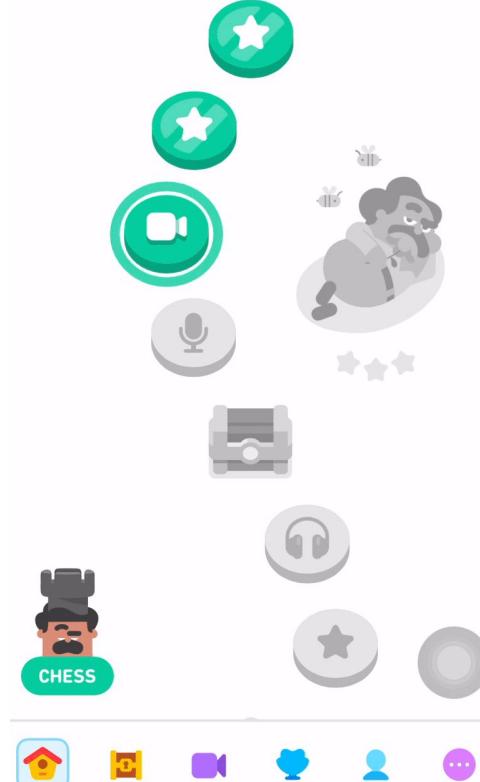
1208



SECTION 1, UNIT 3
Use adjectives

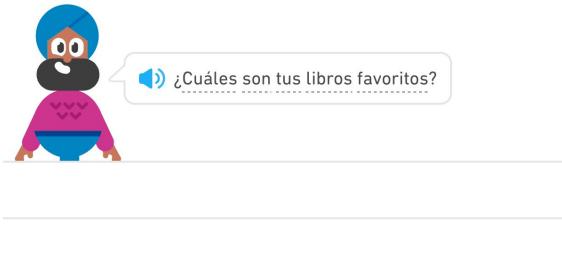


each course
needs a lot
of content



just to create the new sentences
it take around 600 hours per
course!

Write this in English



¿Cuáles son tus libros favoritos?

park are good your What favorite

books to learn bedroom





and we want rich content





X

5



Voyage en Espagne

Vikram parle avec son amie, Béa.



Salut, Béa ! Comment ça va ?



Super ! Je suis très contente d'aller en
Espagne !

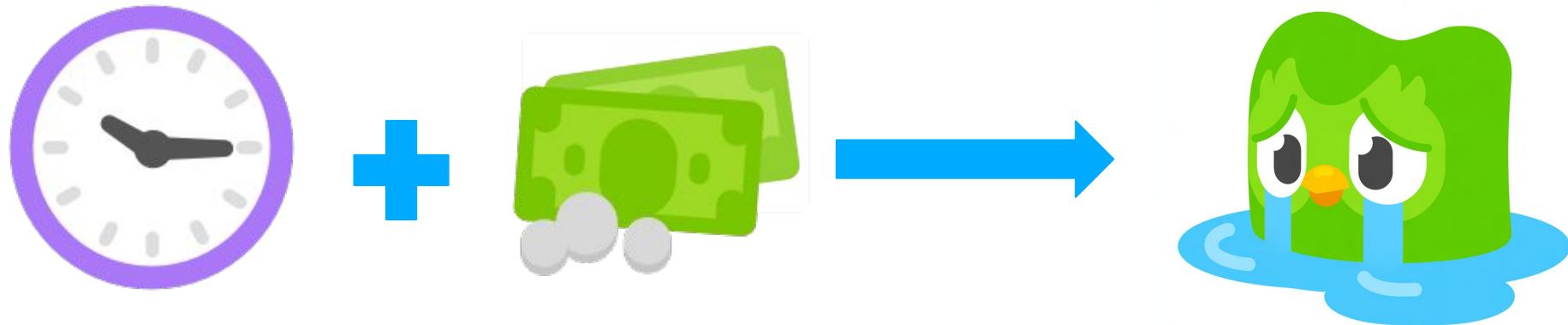


The screenshot shows the Duolingo Spanish Podcast page. At the top, there's a large green banner with the text "Duolingo Spanish Podcast". Below the banner, there's a section for "All Episodes" featuring two episodes: "Duo's Film Club - Fresa y chocolate" (published Feb 29, 18 min 27 sec) and "Duo's Film Club - Coco" (published Feb 22, 17 min 46 sec). To the right of the episodes, there's an "About" section with a detailed description of the podcast, mentioning it's for English speakers learning Spanish and is hosted by Martina Castro. At the bottom right, there's a trailer for "Season 3" with a 4.7-star rating and links to Culture, Education, and Society categories.

stories podcasts



but this is timely + expensive





the result



limited courses

A screenshot of a social media thread from a forum. The thread discusses the availability of Persian language courses, particularly on Duolingo. The posts are as follows:

- guitarelf1f** (2 years ago): 2014. It comes up in every single discussion about this topic, and Duolingo already did every other major language in the region except Persian.
Replies: 70, Award, Share, ...
↳ **guitarelf1f** (2 years ago): Wait as a Persian I'm glad y'all wanna learn our language it's an honor!
↳ **icameisawicame24** (2 years ago): Would love to learn Persian.
↳ **Curry_pan** (2 years ago): I've been waiting for Persian for so long! We can only hope.
↳ **Toothless-Rodent** (2 years ago): Persian is my personal top choice.
↳ **Hoita** (2 years ago): Native Banana speaker
↳ **martinhe333** (2 years ago): It would be great to have Te Reo Māori. I read that there were pushback, as that effort was unsupervised.
- icameisawicame24** (2 years ago): Would love to learn Persian.
↳ **Curry_pan** (2 years ago): I've been waiting for Persian for so long! We can only hope.
- Toothless-Rodent** (2 years ago): Persian is my personal top choice.
↳ **Hoita** (2 years ago): Native Banana speaker
↳ **martinhe333** (2 years ago): It would be great to have Te Reo Māori. I read that there were pushback, as that effort was unsupervised.



limited content per course

A screenshot of a forum thread from a platform like Reddit. The thread discusses the lack of stories in various languages within a language-learning app. The posts are as follows:

- DantheCat7** · 2y ago
I wish every language has stories, hearing stories in Haitian creole, Russian, and Hebrew would be so awesome
(-) Up 65 Down Award Share ...
- Garfunkeled1920** · 2y ago
Agree. I think it's a major deficiency, but I cannot imagine those languages have enough users (or could draw enough users) to justify the creation cost. Duo is, after all, primarily a Spanish-language-learning app that also dabbles in other languages.
Up 14 Down Award Share ...
- Dm_Me_TwistedFateR34** · 2y ago
N, C2, learning
Spanish stories send me to the moon sometimes, they're so absurd and hilarious at times
Up 30 Down Award Share ...
- markisnotcake** · 2y ago
n f learning
There are no stories for any nordic language. :c
(-) Up 21 Down Award Share ...
- Wolke_01** · 2y ago
(N) (C1) (A2)



but then the quality of
LLM generation
improved...

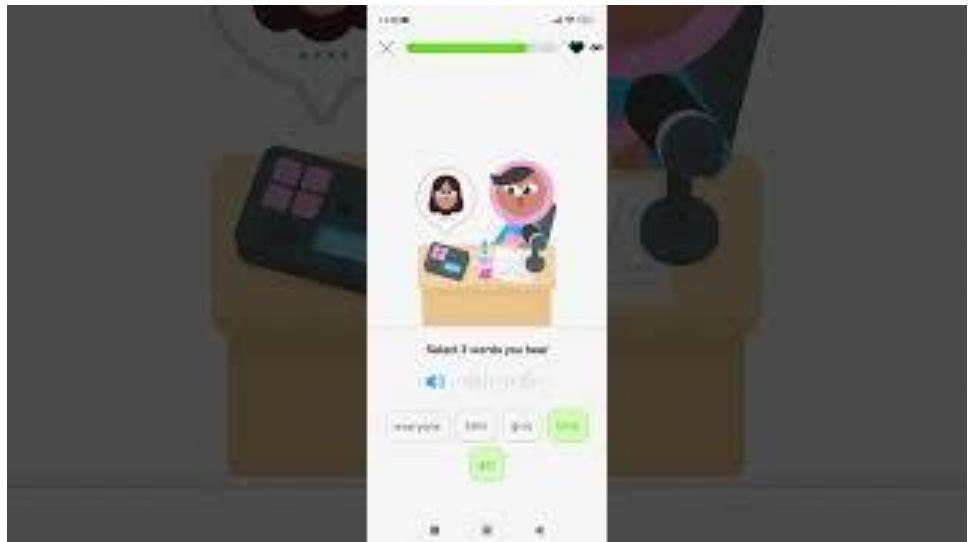
so much that LLMs
can generate our
content to speed us
up



example



a Duoradio
takes 6 hours
with LLMs+
human review





okay ... problem solved





hold your horses



limitations to genai scalability

engineering costs increasing

as we implemented new ai approaches,
we had fragmented tooling landscape

- Bespoke one-off endpoints on existing services → technical debt
- No easy way to share and reuse logic across workflows → reinventing the wheel
- Homegrown orchestration was non-trivial to scale





enter Airflow



DuoFactory

A screenshot of the Airflow web interface. At the top, there are navigation links: Airflow, DAGs, Cluster Activity, Datasets, Security, Browse, Admin, Docs, and Other. Below this is a search bar with the placeholder "Looking for DuoFactory help? Start here!" and a close button. The main area is titled "DAGs" and shows a list of DAGs. The list includes: add_cb_exercises_tags, add_topic_can_do_grammar_to_scope_and_sequence, ai_art_pipeline_for_vocab_object, airflow-utils-log-analyzer, airflow-utils-truncate-database, apply_manual_review_updates, auto_label_with_prompt_ensemble, backfill_flaishard_alternate_answers, batch_run_test_cases, and benchmark_bt_evaluators. Each entry shows the owner (generally airflow), the number of runs, the schedule, the last run time, and the next run time. The "airflow-utils-truncate-database" DAG is currently running, indicated by a blue circle.

wrapper around
Airflow for genai
orchestration



why airflow was a good
candidate



in-house orchestration is hard

Airflow provides rich
orchestration tooling, including
scheduling, dependency
management, retries, and
observability



modularity

- tasks are reusable logic
 - high ROI of eng work
- easily swap out parts of the pipeline as tech improves



examples of tasks

- read/write google sheets
- read course data
- run prompts
- write to s3 to be viewed in the app



idempotency

each step in a DuoFactory DAG
can be retried safely without
corrupting data or producing
inconsistent result

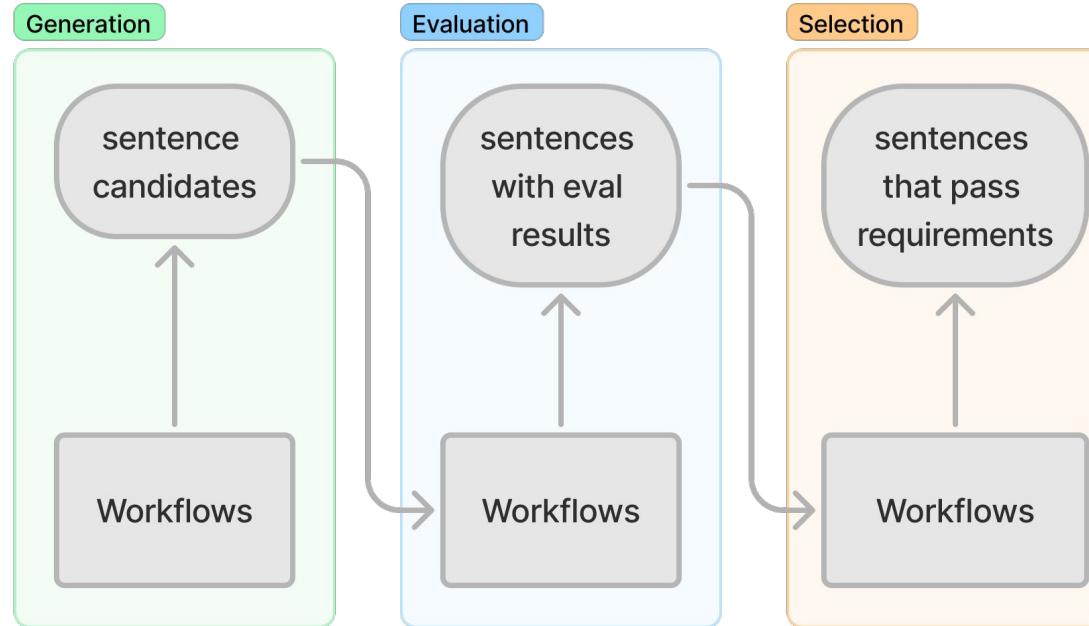


ecosystem compatibility and extensibility

Airflow integrates easily with Duolingo's existing AWS, PostgreSQL, and Terraform-based infrastructure



Duofactory in action

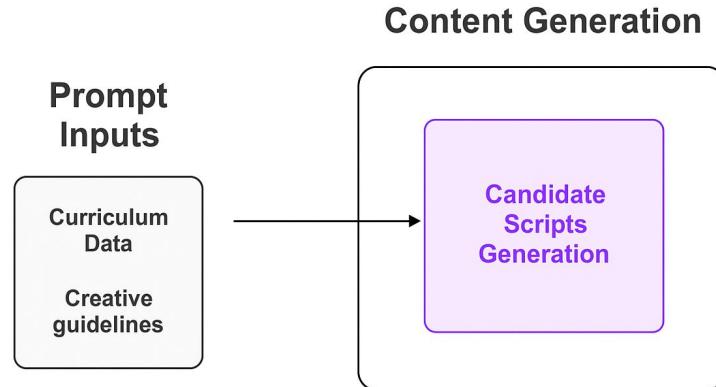




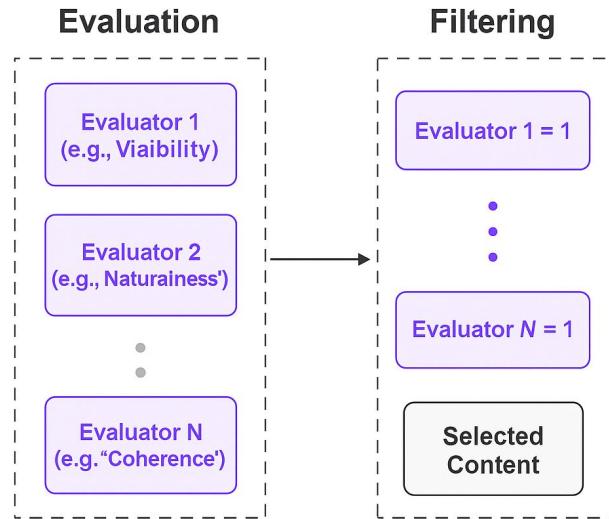
example
Duoradio generation



script generation DAGs



script evaluation DAG





then repeat for exercises
generation -> evals -> selection



extending to end to end

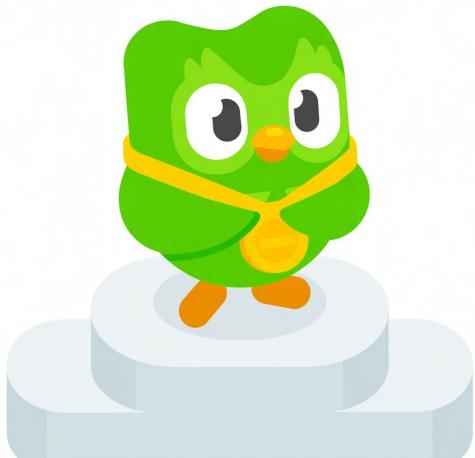




formatting DAG

- API calls to TTS/Viseme generation

publishing DAG



wins

created a pipeline to
generate duoradio
episodes with 0
minutes of human
intervention





cut costs by 99%





impact

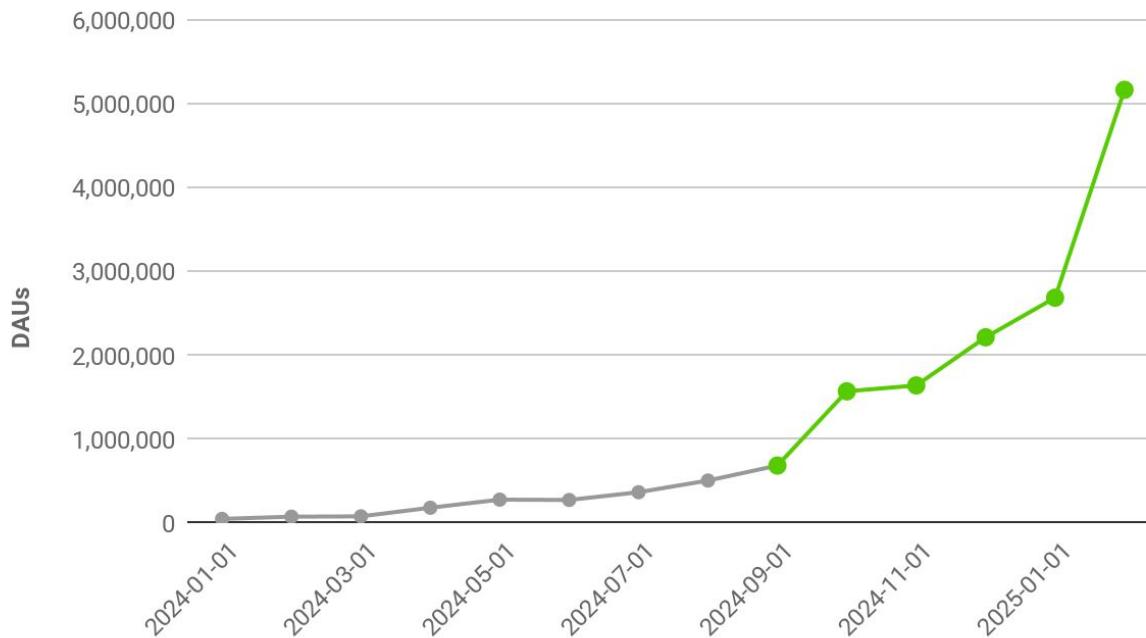


launched duoradio in 243
courses

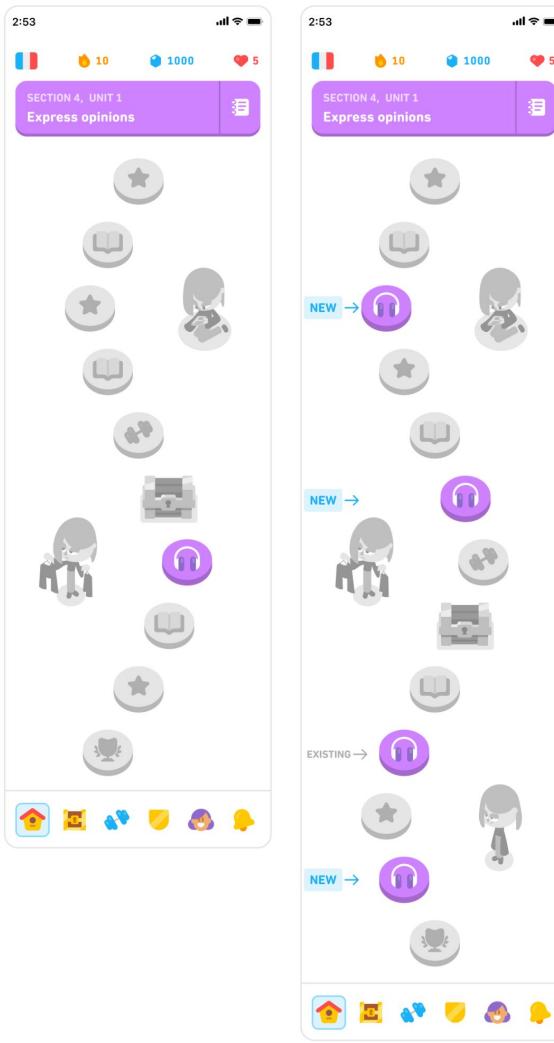




reaching more learners



more
episodes
per unit





expanding the ecosystem





prompt editor



P ← HOME belle test ⚭ / DRAFT Version 1 ▾ PUBLISH VERSION ▾ RUN PROMPT

Chat Template

- 1 System Message** SWITCH TYPE
- The prompt sent by the system...
- 2 User Message** SWITCH TYPE
- The prompt sent by the user...
- + Create New Step**
- 3 Assistant Message** SWITCH TYPE
- Auto Generate this Message

[VIEW JSON](#)

Input Variables

No variables were found in your prompt.
In your prompt, you can define a custom variable using the {{myVariableName}} syntax.
For image variables, use {{image:myImageName}} syntax.
Image variables need to be put at the end of the message. For example, describe the image {{image:image1}}.

Chat

A cartoon owl with large eyes, wearing a small orange vest, holding a pencil and a book.

RUN YOUR PROMPT

You'll see messages after running the prompt.
Use Command + Enter, or click Run Prompt.

Model Configuration

Output Variables



google sheets



	A	B	C	D	E	F	G	H	I	J	K	L	M		
1	wrapper_name	section_type	variability_type	en	es	fr	de	pt	it	ja	hi	ko	ru	vi	
2	Lily and Strangers	intro	fixed	Welcome to "Lily and Strangers," where I'm forced to talk to people I don't know.	Les doy la bienvenida a todos los que no me conocen.	Bienvenue dans l'émission "Lily and Strangers" où je suis contraint de parler avec des personnes que je ne connais pas.	Willkommen bei "Lily and Strangers", wo ich mit Leuten sprechen muss, die mich nicht kennen.	Olá. Esse é o "Lily and Strangers", onde tenho que falar com pessoas que não me conhecem.	Vi diamo il benvenuto all' "Lily and Strangers", dove ho dovuto parlare con persone che non mi conoscono.	こんにちは。「リ」「莉」と「ストレンジャー」の「Lily and Strangers」。私は知らない人に話さなければなりません。	Привет. Это шоу "Lily and Strangers". Я вынужден общаться с людьми, которых не знаю.	Xin chào.			
3	Lily and Strangers	intro	semi_fixed	1) I'm Lily and here's our new guest... Let's get this over with. 2) I'm Lily, and today we have another guest who wants to talk to us. 3) I'm Lily, and today we're listening to another stranger... Let's go. 4) I'm Lily, and today we have another person here to waste time.	1a) Soy Lily, y er (1a) Je m'appelle 1b) Soy Lily, y er (1b) Je m'appelle	1a) Eu sou a Lily 1b) Eu sou a Lily	1a) Soy Lily, y er (1a) Je m'appelle 1b) Soy Lily, y er (1b) Je m'appelle	1a) Eu sou a Lily 1b) Eu sou a Lily	1) メンツの新規ゲストが登場。やあ、おめでたそー。 2) メンツのゲストが登場。今日はおしゃべりを楽しみたい。 3) メンツのゲストが登場。今日は他のメンツの話を聞く。 4) メンツのゲストが登場。今日は他のメンツと一緒に時間を過ごす。						
4	Lily and Strangers	outro	fixed	See you next time... or not...	Hasta la próxima!	Até a próxima!	Bis zum nächsten Mal!	Alla prossima!	では、また次回! キミに会ふる... やあ、また! 普段から見つけてるやつだ。	Olá, esse é o "Lily and Strangers".					
5	Lucy Is Listening	intro	fixed	Welcome back to "Lucy Is Listening," where I uncover hidden Te doy la bienvenida a todos los que no me conocen.	Bienvenue dans l'émission "Lucy Is Listening" où je dévoile les secrets.	Willkommen bei "Lucy Is Listening", wo ich Geheimnisse entdecke.	Vi do o benvenuto alla "Lucy Is Listening", dove scoprirete i misteri.	Vi diamo il benvenuto alla "Lucy Is Listening", dove scoprirete i misteri.	こんにちは。「ルーシー」「リスニング」の「Lucy Is Listening」。今日は隠された秘密を発見します。	Привет. Это шоу "Lucy Is Listening". Сегодня я буду открыть некоторые тайны.	Xin chào.				
6	Lucy Is Listening	intro	semi_fixed	I'm your host, Lucy, and today we're listening to two people [+ Soy tu anfitriona]	Te doy la bienvenida a mis invitados hoy.	Bienvenue dans l'émission "Lucy Is Listening" où je dévoile les secrets.	Willkommen bei "Lucy Is Listening", wo ich Geheimnisse entdecke.	Vi do o benvenuto alla "Lucy Is Listening", dove scoprirete i misteri.	Vi diamo il benvenuto alla "Lucy Is Listening", dove scoprirete i misteri.	こんにちは。「ルーシー」「リスニング」の「Lucy Is Listening」。今日は二人のゲストを聴いています。	Привет. Это шоу "Lucy Is Listening". Сегодня я буду открыть некоторые тайны.	Tôi là			
7	Lucy Is Listening	outro	fixed	I'll get to the bottom of this. Remember, I'm always listening... Llegaré al fondo.	Te doy la bienvenida a mis invitados hoy.	Je découvre tout ce qui se passe dans l'émission.	Ich werde der Sache auf den Grund gehen.	Vamos desverdaderamente a fondo.	Andró a fondo de todo.	私はこの問題の底に達する。覚えておいて、私はいつも聴いています。	私はこの問題の底に達する。覚えておいて、私はいつも聴いています。	私はこの問題の底に達する。覚えておいて、私はいつも聴いています。	私はこの問題の底に達する。覚えておいて、私はいつも聴いています。	私はこの問題の底に達する。覚えておいて、私はいつも聴いています。	
8	Vikram's Community Hotline	intro	fixed	Welcome to "Vikram's Community Hotline," where members call in to ask questions.	Les doy la bienvenida a todos los que tienen preguntas.	Bienvenue dans l'émission "Vikram's Community Hotline".	Willkommen bei "Vikram's Community Hotline".	Queridos oyentes, bienvenidos.	Vi diammo il benvenuto alla "Vikram's Community Hotline".	こんにちは。「ヴィクラム」「コミュニティ」「ホーリン」の「Vikram's Community Hotline」。今日は質問があります。	Привет. Это шоу "Vikram's Community Hotline". Сегодня мы будем отвечать на вопросы.	Chào			
9	Vikram's Community Hotline	intro	semi_fixed	I'm your host, Vikram, and today's message is all about [subje Soy tu anfitriona, Je m'appelle Vikram]	Te doy la bienvenida a todos los que tienen preguntas.	Bienvenue dans l'émission "Vikram's Community Hotline".	Willkommen bei "Vikram's Community Hotline".	Queridos oyentes, bienvenidos.	Vi diammo il benvenuto alla "Vikram's Community Hotline".	こんにちは。「ヴィクラム」「コミュニティ」「ホーリン」の「Vikram's Community Hotline」。今日は質問があります。	Привет. Это шоу "Vikram's Community Hotline". Сегодня мы будем отвечать на вопросы.	Tôi là			
10	Vikram's Community Hotline	intro	fixed	Let's hear from our first caller.	Escuchemos a nuestros primeros oyentes.	Écoutons nos premiers auditeurs.	Hören wir uns von unseren ersten Hörern.	Hören wir uns von unseren ersten Hörern.	Hören wir uns von unseren ersten Hörern.	私たちの最初の電話通話者からお聞きください。	У нас уже есть! Vá saudar.	Слушаю первого звонка.			
11	Vikram's Community Hotline	outro	fixed	Thank you for joining us on "Vikram's Community Hotline." Re Gracias por escuchar.	Gracias por escuchar.	Merci d'écouter.	Das war „Vikram's Community Hotline.“	Merci d'écouter.	Das war „Vikram's Community Hotline.“	ありがとうございます。MC ヴィクラム	Меня зовут Вик.	Спасибо, что присоединились к нам в "Vikram's Community Hotline".			
12	Oscar's Antique Roadshow	intro	fixed	I'm your host, Oscar, and this is "Oscar's Antique Roadshow."	Soy tu anfitriona, Je m'appelle Oscar.	Soy tu anfitriona, Je m'appelle Oscar.	Soy tu anfitriona, Je m'appelle Oscar.	Soy tu anfitriona, Je m'appelle Oscar.	Soy tu anfitriona, Je m'appelle Oscar.	オскаー	Оскар	オскаー	Оскар		



content management system



DuoRadio / Prod
EN < ES

Search by episode name or ID FILTER

<input type="checkbox"/>	EPISODE NAME	VIABILITY	WRAPPER	STATUS	SLOT	SCHEMA VERSION	Pipeline Status	GLOBAL ATTEMPTS	LAST UPDATED	⋮	⋮
▼ Empleos (A1.0 – 63f532236a038ee957b7154aaddbcd)											
<input type="checkbox"/>	Work in Chicago	0.85	Lily and Strangers	PUBLISHED	0	3	Published	2	12/15/2024 3:46 AM EST	⋮	⋮
<input type="checkbox"/>	Interesting Job	0.86	Falstaff's Guide to Humans	PUBLISHED	0	duoradio_a1_flagships	Published	1	6/20/2025 12:13 PM EDT	⋮	⋮
<input type="checkbox"/>	Are You a Doctor?	0.86	Lucy Is Listening	PUBLISHED	1	duoradio_a1_flagships	Published	1	6/20/2025 12:13 PM EDT	⋮	⋮
<input type="checkbox"/>	Artists and Offices	0.85	Lucy Is Listening	PUBLISHED	1	3	Published	1	11/20/2024 6:56 PM EST	⋮	⋮
<input type="checkbox"/>	Work at the Hospital	0.87	Late Nights with Lin	PUBLISHED	2	duoradio_a1_flagships	Published	1	6/20/2025 12:13 PM EDT	⋮	⋮
<input type="checkbox"/>	Meeting Humans	0.87	Falstaff's Guide to Humans	PUBLISHED	2	3	Published	1	11/20/2024 8:38 PM EST	⋮	⋮
▼ Encuentros (A1.0 – 46f57661460e7b1621fed84e29bc0720)											
<input type="checkbox"/>	A Bilingual Encounter	0.94	Lucy Is Listening	PUBLISHED	1	duoradio_a1_flagships	Published	1	6/20/2025 12:13 PM EDT	⋮	⋮
<input type="checkbox"/>	Nice to Meet You	0.92	Falstaff's Guide to Humans	PUBLISHED	1	3	Published	1	11/20/2024 11:14 PM EST	⋮	⋮
<input type="checkbox"/>	Do You Speak English?	0.94	Falstaff's Guide to Humans	PUBLISHED	2	duoradio_a1_flagships	Published	1	6/20/2025 12:13 PM EDT	⋮	⋮
<input type="checkbox"/>	Suspicious Nice to Meet You	0.96	Lucy Is Listening	PUBLISHED	2	3	Published	1	11/20/2024 10:15 PM EST	⋮	⋮
<input type="checkbox"/>	Conversation in Two Languages	0.85	Falstaff's Guide to Humans	PUBLISHED	3	duoradio_a1_4_nodes_flagship	Published	2	7/14/2025 2:11 PM EDT	⋮	⋮

prod





workflow builder
codeless DAG
using predefined
building blocks



← HOME A1 DuoRadio Title, Exercises & Formatting for Lucy IT<EN ⚡

SAVE SAVE AND RUN VIEW RESULTS

P

IMPORT
PROMPT
EVALUATE
EVALUATE (PARALLEL)
SORT
SELECT
CUSTOM

```
graph TD; Import1[Import 1<br/>Import using Google Sheets] --> Prompt1[Prompt 1<br/>A1 DR episode title (UI)<br/>Run prompt 1 time(s.)]; Prompt1 --> Prompt2[Prompt 2<br/>A1 DuoRadio 3-in1 exercises: Listen+Comp+CAP<br/>Run prompt 2 time(s.)]; Prompt2 --> Evaluate1[Evaluate 1<br/>Evaluate using Loading...]; Evaluate1 --> Prompt3[Prompt 3]
```

Detailed description: This screenshot shows the Airflow UI for creating a data pipeline. On the left, there's a sidebar with icons for Pencil (Edit), a blue circle with 'P' (Home), a blue circle with '3' (Recent), and a plus sign (New). Below these are buttons for IMPORT, PROMPT, EVALUATE, EVALUATE (PARALLEL), SORT, SELECT, and CUSTOM, each with a corresponding icon. The main workspace contains five rectangular boxes connected by arrows. From top to bottom: 1) 'Import 1' (Import using Google Sheets). 2) 'Prompt 1' (A1 DR episode title (UI)). 3) 'Prompt 2' (A1 DuoRadio 3-in1 exercises: Listen+Comp+CAP). 4) 'Evaluate 1' (Evaluate using Loading...). 5) 'Prompt 3'. Each box has a red trash can icon in the top right corner. At the top of the workspace, there are buttons for 'SAVE', 'SAVE AND RUN', and 'VIEW RESULTS'.



each workflow block maps to a corresponding DAG based on its type and metadata



execution flow

- load workflow definition from the workflow table
- trigger the corresponding block-type DAG, passing outputs from the previous block
- use `should_execute()` to stop once workflow completion is detected



static architecture constraint

DAGs require a fixed structure known at scheduling time... but we get the definition at run time

always iterate MAX_BLOCKS times, even if some iterations are skipped



```
workflow_id = cast(WorkflowId, "{{ params.workflow_id }}")  
use_local_db = cast(bool, "{{ params.use_local_db }}")  
workflow = get_workflow(workflow_id=workflow_id, use_local_db=use_local_db)  
blocks = get_workflow_blocks(wf=workflow)
```



```
for i in range(MAX_BLOCKS):
    # For downstream blocks, pass the output of the previous block as the `payloads` parameter
    # If the previous outputs are empty, seed the first block with an empty payload
    payloads = previous_block_output or [Payload(block_results={})]

    # This returns both the first task and the actual output of the @task_group so we can set
    # the dependencies correctly
    first_task, current_block_output = run_current_block.override(
        default_args={
            "trigger_rule": TriggerRule.ALL_SUCCESS,
        },
        group_id=f"run_current_block_{i}",
    )(

        global_vars=cast(dict[str, Any], "{{ params.global_variables }}"),
        index=i,
        input_payloads=payloads,
        wf=workflow,
        wf_id=workflow_id,
        use_local_db=use_local_db,
    )

    if previous_block_output:
        # Short circuit the current block if we are at the end of the workflow
        # This will cause the downstream blocks to be skipped (until the final task group,
        # which has its own trigger rules, since we need to store the results at the end.)
        short_circuit = should_execute.override(
            ignore_downstream_trigger_rules=False,
            task_id=f"short_circuit_{i}",
            trigger_rule=TriggerRule.ONE_SUCCESS,
        )(

            curr_block=i,
            n_blocks=num_blocks,
        )
        chain(previous_block_output, short_circuit, first_task)

    previous_block_output = set_latest_output_payloads.override(
        task_id=f"set_latest_output_payloads_{i}",
    )(current_block_output, previous_block_output)
```

thank you





questions?



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[@isabel-romea](https://www.linkedin.com/in/isabel-romea)