US 20250259018A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0259018 A1**

Kocienda et al. (43) **Pub. Date: Aug. 14, 2025**

(54) **INTERCHANGEABLE LARGE LANGUAGE MODELS FOR CONTEXT COMPUTING DEVICES**

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(21) Appl. No.: **19/048,836**

(22) Filed: **Feb. 7, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/552,075, filed on Feb. 9, 2024.

Publication Classification

(51) **Int. Cl.**

G06F 40/40 (2020.01)

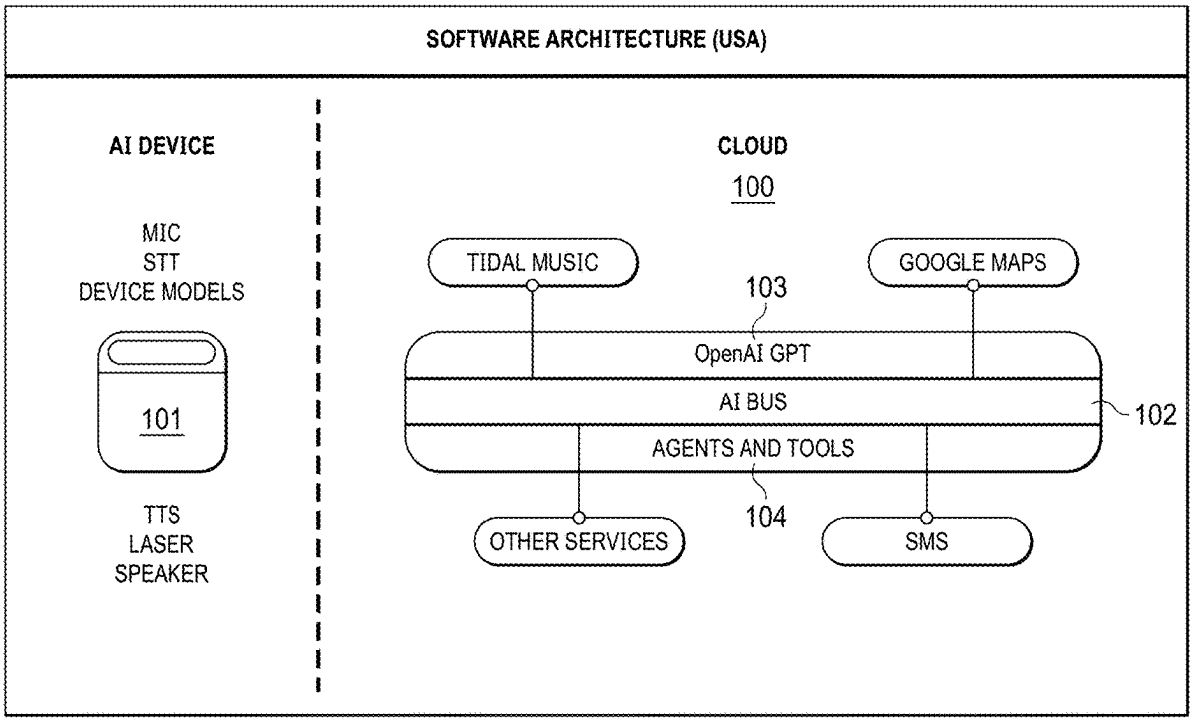
G06F 40/30 (2020.01)

(52) **U.S. Cl.**

CPC ***G06F 40/40*** (2020.01); ***G06F 40/30*** (2020.01)

(57) **ABSTRACT**

This disclosure relates generally to the management of large language models on artificial intelligence (Ai) enabled devices. In some embodiments, a method comprises: receiving, from a device, a request for information, the request including text-input and context data; determining, with at least one processor, a large language model from a plurality of large language models based at least in part on the context data; providing, with the at least one processor, the text-input, or input data derived from the text-input into the large language model; and sending the output of the large language model, or data derived from the output of the large language model to the device for further processing or output by the device or another device.



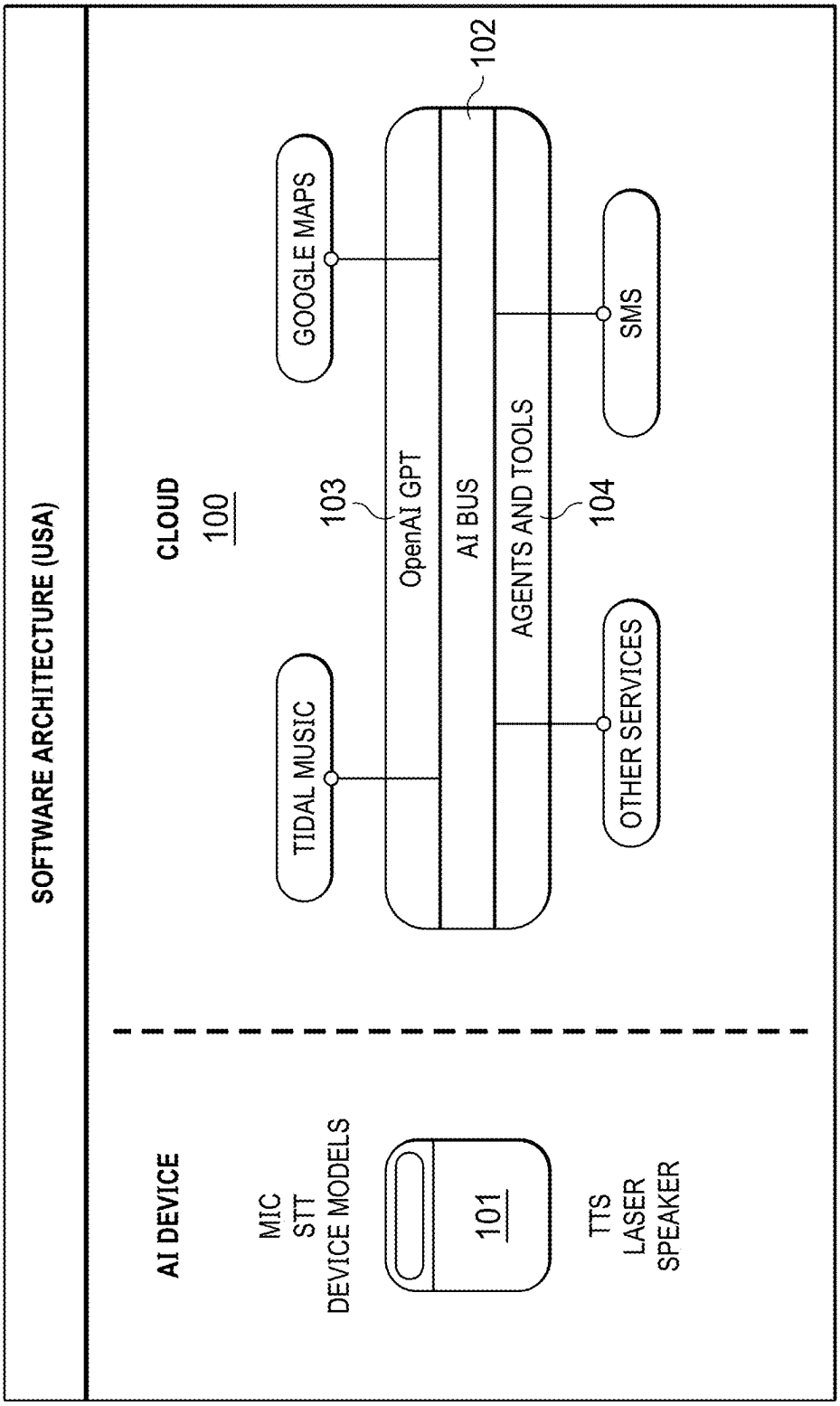
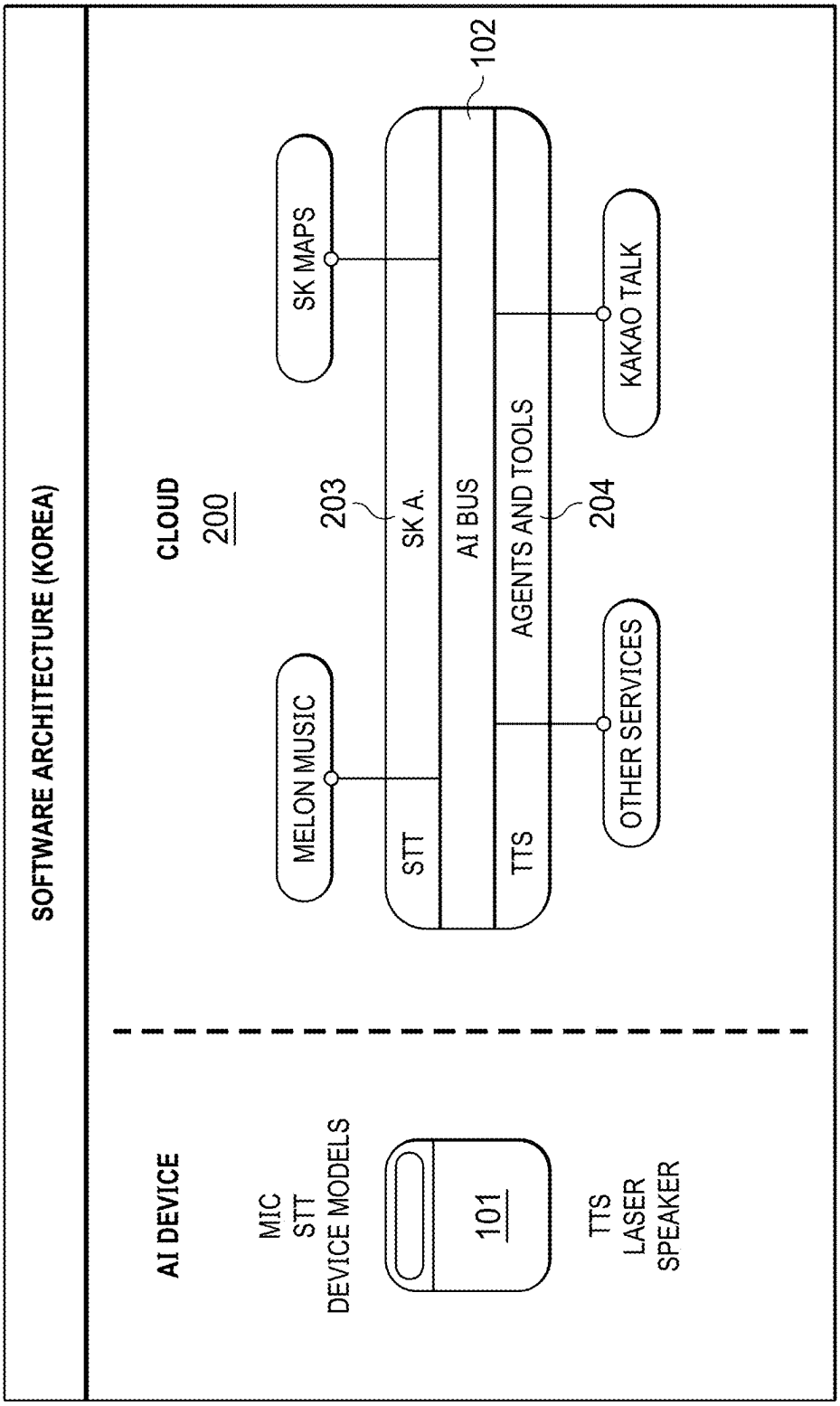

SOFTWARE ARCHITECTURE (USA)
AI DEVICE
MIC
STT
DEVICE MODELS
101
TTS
LASER
SPEAKER
CLOUD
100
102
103
104
OpenAI GPT
AI BUS
AGENTS AND TOOLS
GOOGLE MAPS
SMS
TIDAL MUSIC
OTHER SERVICES

FIG. 1


SOFTWARE ARCHITECTURE (KOREA)
AI DEVICE
MIC
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101
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LASER
SPEAKER
CLOUD
200
MELON MUSIC
SK MAPS
203
SK A.
STT
AI BUS
TTS
AGENTS AND TOOLS
204
102
KAKAO TALK
OTHER SERVICES

FIG. 2

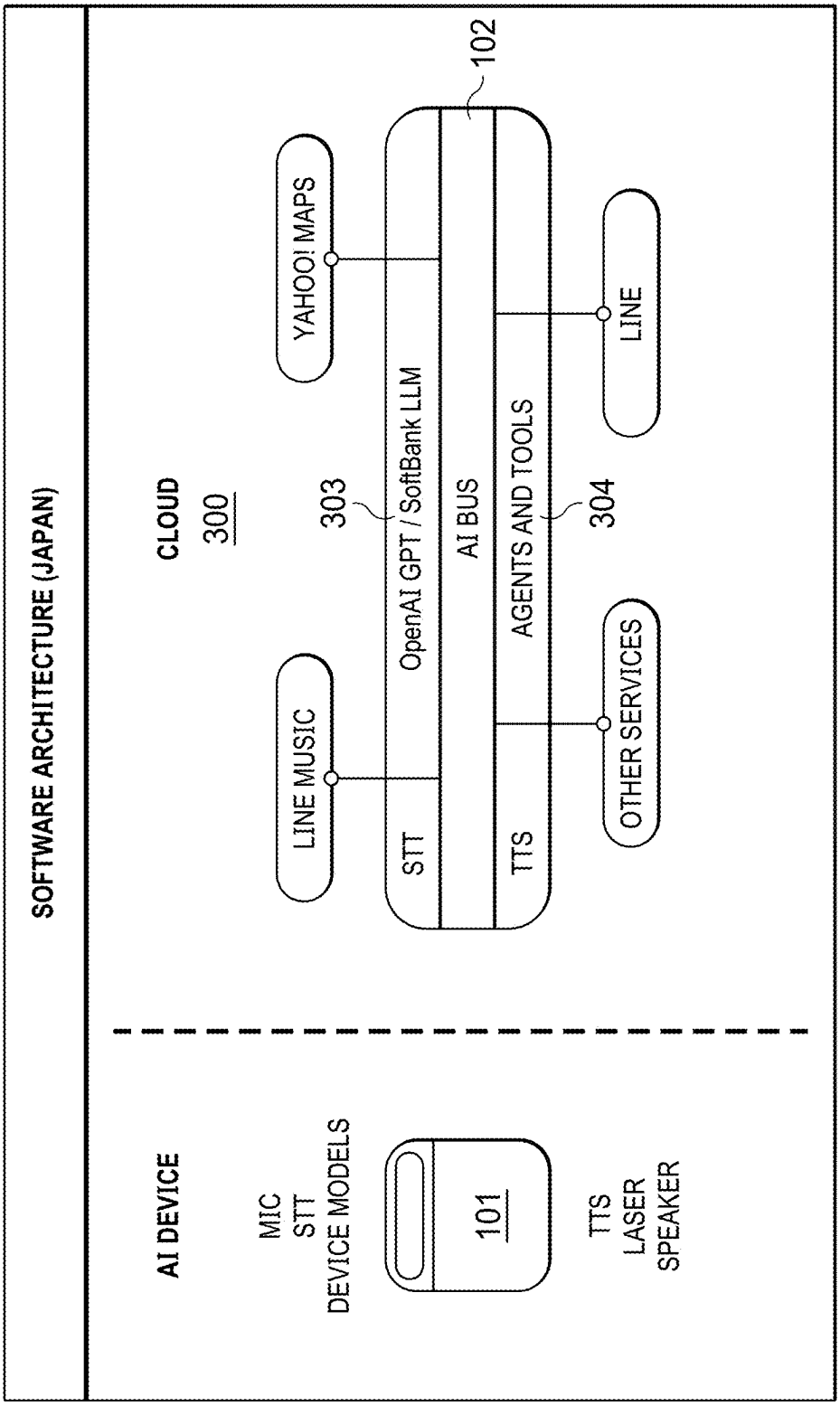
SOFTWARE ARCHITECTURE (JAPAN)
AI DEVICE
MIC
STT
DEVICE MODELS
101
TTS
LASER
SPEAKER
CLOUD
300
303
OpenAI GPT / SoftBank LLM
STT
LINE MUSIC
AI BUS
102
TTS
AGENTS AND TOOLS
304
OTHER SERVICES
YAHOO! MAPS
LINE

FIG. 3

INTERCHANGEABLE LARGE LANGUAGE MODELS FOR CONTEXT COMPUTING DEVICES

RELATED APPLICATION

[0001] This application claims the benefit of priority from U.S. Provisional Application No. 63/552,075, filed Feb. 9, 2024, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] This disclosure relates generally to large language models.

BACKGROUND

[0003] A large language model (LLM) is typically used for general-purpose language generation. An LLM can be implemented as an artificial neural network that is built with a transformer-based architecture or other architectures, such as recurrent neural network (RNN) variants or a structured state space sequence (S4) model (e.g., Mamba). LLMs learn statistical relationships from text documents during a self-supervised and semi-supervised training process. LLMs can be used for text generation by taking an input text and repeatedly predicting a next token or word. Some examples of LLMs include Open AI's GPT series (e.g., GPT-3.5 and GPT-4 used in ChatGPT), A Dot LLM (which is specialized for the Korean language) and SoftBank LLM (which is specialized for the Japanese language).

SUMMARY

[0004] An LLM used by a device (e.g., a context-aware device) is determined from multiple LLMs based on context data and/or other data provided by the device and/or other sources (e.g., personal information databases). The LLM can be customized per geographic region to satisfy particular cultural, language, or service requirements. The interchangeability of the LLM serves the need to properly interact with these cultures, languages, or services. The LLM can be determined based on the language of the user captured by a microphone of the device. The LLM can be determined based the language selected by the user for device. In some embodiments, the LLM can be determined based on a setting selected by the user in a settings menu or other input mechanism. In some embodiments, a standard LLM (e.g., language agnostic LLM) can be used to categorize a request, and then forward that request to a particular LLM (e.g., an LLM specialized to a particular language) based on the categorization.

BRIEF DESCRIPTION OF DRAWINGS

[0005] FIG. **1** illustrates a software architecture for swappable LLMs, where the LLM is customized for the United States, according to one or more embodiments.

[0006] FIG. **2** illustrates a software architecture for swappable LLMs, where the LLM is customized for Korea, according to one or more embodiments,

[0007] FIG. **3** illustrates a software architecture for swappable LLMs, where the LLM is customized for Japan, according to one or more embodiments.

DETAILED DESCRIPTION

[0008] The embodiments described below are applicable to an operating system (OS) for an Ai enabled device such as, for example, a wearable computer that uses an LLM for contextual computing, such as described in U.S. Pat. No. 10,924,651, for "Wearable Multimedia Device and Cloud Computing Platform with Application Ecosystem," issued Feb. 21, 2021, which is incorporated by reference herein in its entirety. The disclosed embodiments, however, are also applicable to any device that utilizes LLMs. An example commercial product is the contextual computing device, "Ai Pin", developed by Humane Inc., of San Francisco, California USA, which uses an operating system called "Cosmos," that utilizes LLMs.

[0009] The device can include various input mechanisms, such as, for example, an ephemeral user interface projected on a surface by a laser beam scanning projector of the device, a touch screen, surface or pad, and one or more microphones. The device can also include various output mechanisms, such as, e.g., computer display or monitor, an ephemeral laser projected display, a loudspeaker, LED lights, etc. The device can be an augmented/virtual/extended reality headset, glasses, goggles, chest mounted or wrist mounted device.

[0010] When a user interacts with the device, the interaction can be in the form of speech, gestures on a touchpad, or interaction with laser projected ephemeral user interface projected by the device on a surface (e.g., projected on the user's hand). In all of these interactions, the OS renders the input request (or event) into a natural language representation, encapsulating the actual input (what the user actually said or did) with some metadata about the form of the input (e.g., speech, gesture, etc.) and some system context (e.g., location, time of day, etc.).

[0011] FIG. **1** illustrates a cloud computing platform **100** for swappable LLMs where the LLM is customized for the United States, according to one or more embodiments, according to one or more embodiments.

[0012] An Ai device **101** contacts cloud computing platform **100** and sends the input (e.g., text-based input) and context data in the form of a request to a system bus **102** on cloud based platform **100**. The system bus **102** unpacks the information received from the device **101** with the request and submits the text to an LLM **103** to determine the intent of the request. The LLM **103** processes the text and consults an array of available agents/tools/or services **104** on cloud platform **100** to respond to the request. The LLM **103** builds a plan for how to satisfy the intent using one or more of these agents/tools/services **104** (e.g., music service, map service). In this example, the LLM **103** is customized for the US culture, language, services, etc. For example, in FIG. **1** the LLM **103** is OpenAI GPT and services **104** include Google Map®s, Tidal Music® and SMS messaging service.

[0013] In some embodiments, text to speech (TTS) conversion is performed on device **101**. In other embodiments, text to speech (TTS) and speech to text (STT) conversion is performed on cloud computing platform **100**.

[0014] In some embodiments, the LLM **103** may restructure the input request information into a form suitable for processing and may add an additional request to consult additional context data (e.g. personal information databases that the user opts into) that are available on or accessible from the cloud computing platform **100**. The LLM **103** communicates this plan back to the system bus **102** for

processing. The system bus **102** invokes the agents, tools, and/or services **104** with the input information and additional context (if any). Once this processing is completed, the system bus **102** consults the LLM **103** once more to determine if the intent of the request has been met. If the intent is not met, the system bus **102** repeats the foregoing steps. If the intent of the request has fully been met, the LLM **103** is consulted once again to format a response. This response includes sufficient information to determine what experience to invoke on the device **101**, such as, e.g., text to speech back to the user via voice, and/or content projected in laser ink on a surface by a laser projector of the device **101**.

[0015] In all the above steps, the LLM **103** is interchangeable. For example, the LLM **103** can be customized per geographic region to satisfy particular cultural, language, or service requirements. The interchangeability of the LLM **103** serves the need to properly interact with these cultures, languages, or services.

[0016] FIG. **2** illustrates a cloud computing platform **200** where the LLM is customized for Korea, according to one or more embodiments. In particular, the LLM **203** is customized for the Korean cultures, language, services, etc. For example, in FIG. **2** the LLM **203** is the SK Telecom® Co. Korean LLM "A." or "ADot" which is specialized for the Korean language, and the services **204** include Melon Music®, SK Maps and Kakao Talk messaging service.

[0017] FIG. **3** illustrates a cloud computing platform **300** where the LLM **303** is customized for Korea, according to one or more embodiments. In particular, the LLM **303** is customized for the Korean cultures, language, services, etc. In particular, the LLM **303** is OpenAIR GPT or SoftBank® LLM which is specialized for the Japanese language, and the services **304** are Line Music®, Yahoo®! Maps and Line® messaging service.

[0018] In some embodiments, the agents **104**, **204**, **304** are LLM-powered subprocesses allowing the operating system to work in a composable fashion. The agents/tools/services **104**, **204**, **304** can be traditional, non-AI powered code and application programming interfaces (APIs) which are available for direct invocation on the system bus **102**, **202**, **203**, on the cloud computing platform **100**, **200**, **300**, e.g., various databases. Agents/tools/services **104**, **204**, **304** can be external to the system bus **102**, **202**, **302** and the cloud computing platform **100**, **200**, **300**, e.g. music, messaging, mapping services, etc. Customization can occur at any touch point, and the LLM **103**, **203**, **303** can be abstracted at points where it is called and receives replies from the LLM **103**, **203**, **303**. In this manner, the software architecture is agnostic to LLMs.

[0019] In some embodiments, a one-time setting of a LLM **103**, **203**, **303** can be provided by, for example, a carrier or retail partner to lock in the use of that specific LLM for a particular market or sales environment.

[0020] In some embodiments, the operating system can provide a mapping of the user interface language to the LLM **103**, **203**, **303**, and switch between these different LLMs using this mapping when the user changes the user interface language in, for example, in a settings menu of the device **101**. For example, if the user interface is in English then the LLM **103** can be OpenAI. If the user changes the user interface language to Korean in a settings menu, then the LLM **203** (e.g., ADot) can be automatically swapped into operation.

[0021] In some embodiments, the operating system of device **101** can provide a custom setting which gives the user control over which LLM to use to suit their preferences. For example, some users might prefer an open-source LLM for personal reasons.

[0022] In some embodiments, the choice of LLM can be made on the fly. For example, the operating system can auto-detect the language spoken into a microphone of the device **101** by the user and choose the most appropriate LLM based on the spoken language.

[0023] In some embodiments, the operating system can choose the LLM based on geography (e.g., determined by a GPS or other satellite communication receiver on device **101**). For example, when an American user visits Korea, the LLM can automatically swapped to LLM **203**, the Korea-based LLM (e.g., ADot).

[0024] In some embodiments, the operating system can use a first LLM to categorize a request, and then forward that request to one or more other LLMs based on the categorization. For example, a request to play a song on the Tidal® service might get routed to OpenAI® GPT, while a request to send a Kakao® message might get routed to a Korea-based messaging LLM **203** (e.g., ADot®).

[0025] In some embodiments, the LLMs **103**, **203**, **303** or a portion thereof are downloaded to device **101**, where the LLMs **103**, **203**, **303** process at least a portion of the text data and/or context data. In other embodiments the LLMs **103**, **203**, **303** reside on the cloud computing platform **100**, **200**, **300**. In still other embodiments, the LLMs **103**, **203**, **303** reside on both the device **101** and cloud computing platform **100**, **200**, **300**. The LLMs **103**, **203**, **303** can be downloaded to device **101** based on the context data, such as geography, language spoken, etc.

[0026] In some embodiments, the LLM **103**, **203**, **303** is a DeepSeek™ LLM as described in Xiao Bi et al., "DeepSeek LLM: Scaling Open-Source Language Models with Longtermism," arXiv:2401.02954v1 (5 Jan. 2024).

[0027] The details of the disclosed embodiments are set forth in the accompanying drawings and the description below. Other features, objects and advantages are apparent from the description, drawings, and claims.

[0028] A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. Elements of one or more implementations may be combined, deleted, modified, or supplemented to form further implementations. In yet another example, the logic flows depicted in the figures do not require the particular order shown, or sequential order, to achieve desirable results. In addition, other steps may be provided, or steps may be eliminated, from the described flows, and other components may be added to, or removed from, the described systems. Accordingly, other implementations are within the scope of the following claims.

1. A system comprising:

a communication interface configured to receive a request for information from a device over a network, the request including text-input and context data;

a system bus for determining a large language model from a plurality of large language models based at least in part on the context data;

providing the text-input, or input data derived from the text-input into the large language model; and

sending the output of the large language model, or data derived from the output of the large language model to the device for further processing or output by the device or another device.

2. The system of claim **1**, wherein the context data includes location data.

3. The system of claim **1**, wherein the plurality of large language models are customized for a particular geographic region.

4. The system of claim **1**, wherein the plurality of large language models are customized for a particular culture or language or service.

5. The system of claim **1**, wherein the LLM restructures the request for information into a form suitable for processing and adds an additional request to consult additional context data that are available on or accessible from the network.

6. The system of claim **1**, wherein the request for information is converted to a natural language representation, and the request for information encapsulates and text or speech input from a user with metadata about the form of the actual input.

7. The system of claim **1**, wherein the system bus:

invokes at least one agent, tool, or service on the device based on the request for information;

consults the LLM to determine if the intent of the request for information has been met;

in accordance with the intent of the request not fully being met, resending the request for information;

in accordance with the intent of the request being fully met, requesting the LLM to format a response for presentation on the device.

8. The system of claim **1**, wherein the LLM categorizes the request for information and forwards the request for information to another LLM based on the categorization.

9. The system of claim **1**, wherein the LLM or a portion thereof is downloaded to the device, and processes at least a portion of the text data or context data on the device.

10. The system of claim **1**, wherein the LLM is a DeepSeek™ LLM.

11. A method comprising:

receiving, from a device, a request for information, the request including text-input and context data;

determining, with at least one processor, a large language model from a plurality of large language models based at least in part on the context data;

providing, with the at least one processor, the text-input, or input data derived from the text-input into the large language model; and

sending the output of the large language model, or data derived from the output of the large language model to the device for further processing or output by the device or another device.

12. The method of claim **11**, wherein the context data includes location data.

13. The method of claim **11**, wherein the plurality of large language models are customized for a particular geographic region.

14. The method of claim **11**, wherein the plurality of large language models are customized for a particular culture or language or service.

15. The method of claim **11**, wherein the LLM restructures the request for information into a form suitable for processing and adds an additional request to consult additional context data that are available on or accessible from the network.

16. The method of claim **11**, wherein the request for information is converted to a natural language representation, and the request for information encapsulates and text or speech input from a user with metadata about the form of the actual input.

17. The method of claim **11**, wherein the system bus:

invokes at least one agent, tool, or service on the device based on the request for information;

consults the LLM to determine if the intent of the request for information has been met;

in accordance with the intent of the request not fully being met, resending the request for information;

in accordance with the intent of the request being fully met, requesting the LLM to format a response for presentation on the device.

18. The method of claim **11**, wherein the LLM categorizes the request for information and forwards the request for information to another LLM based on the categorization.

19. The method of claim **11**, wherein the LLM or a portion thereof is downloaded to the device, and processes at least a portion of the text data or context data on the device.

20. The method of claim **11**, wherein the LLM is a DeepSeek™ LLM.

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