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ADJUSTING STREAMING OF SCREEN DATA BASED ON WINDOW VISIBILITY

Abstract

Systems and methods are described for adjusting streaming of screen data from a server to a client based on visibility of the window in which the screen data is presented on the client. Visibility of a window in the graphical user interface (GUI) can be monitored, for example by detecting when the window is minimized or obscured by other objects in the GUI, and the streaming of screen data to the window can be dynamically adjusted based on the window visibility. When the window is minimized or fully obscured, the streaming of screen data can be stopped. When the window is partially obscured, the streaming can be modified such as by decreasing the frame rate.

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Background/Summary

CROSS-REFERENCE [0001] This application is a continuation of U.S. patent application Ser. No. 18/158,415, filed Jan. 23, 2023, which application is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to streaming screen data from a server to a client and more specifically to techniques for adjusting data streams and encoding methods to optimize resource utilization in screen data streaming.

BACKGROUND OF THE INVENTION

[0003] In various streaming technologies, screen data such as frames of a video or a graphical user interface (GUI) of an application or desktop is sent as a stream of pixel data to a client device at the location of a user. For example, when a user accesses a remote desktop or a remote application on a client device, the GUI of the desktop or the application is captured on the server and streamed to the client device to be displayed to the user. Similarly, when a user is watching a video that is streamed from a server, video pixel data is conveyed from the server and displayed on the user's client device.

[0004] In each case, the pixel data is encoded at the server and conveyed to the client device over a network connection. On the client device, the received pixel data is decoded to render frames that are displayed to the user, producing the content (video, GUI, etc.). Generally, the process consumes computing resources of the server (e.g., to encode the screen data), computing resources of the client (e.g., to decode and render the screen data), as well as network resources (e.g., bandwidth) to transmit the screen data. Particularly in the case of high resolution and/or high framerate content, the burden on resources can be substantial.

[0005] While certain expenditure of resources may be necessary for delivering high quality screen content to a user, resources may be wasted when multimedia content is delivered and processed but the window in which the content is to be displayed is fully or partially hidden from a user, such as when the window was minimized or obscured by other objects in the interface. In such cases, even though some content may not be viewable due to the window or parts of it being hidden, resources would nonetheless be consumed for encoding, transmitting, and decoding the screen data.

[0006] What is needed is a more efficient approach for adjusting streaming of screen data based on visibility in the GUI of the window in which the screen data is presented.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1 illustrates an example of a virtual desktop environment, in accordance with various embodiments.

[0008] FIG. 2 illustrates an example architecture of a system for adjusting streaming of screen data based on window visibility, in accordance with various embodiments.

[0009] FIG. 3 illustrates an example process flow for adjusting streaming of screen data based on window visibility, in accordance with various embodiments.

[0010] FIG. 4 illustrates an example of some general components of a computing device, in accordance with various embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Systems and methods in accordance with various embodiments of the present disclosure overcome at least some of the above-mentioned shortcomings and deficiencies by providing efficient ways for adjusting streaming of screen data to a client based on visibility of the window in which the screen data is presented on the client. In particular, embodiments described herein leverage a mechanism for monitoring visibility of a window in the graphical user interface (GUI), for example by detecting when the window is minimized or obscured by other objects in the GUI, and dynamically adjusting the streaming of screen data to the window based on the window visibility.

[0012] Conventionally, when a user viewed a video in a virtual desktop or in a video streaming application, the video could be streamed from the server to the client with standard settings (e.g., high frame rate of 30 fps or higher, high resolution, etc.) and processed by the client for being presented in a client application window even when the window was minimized or obscured in the GUI (e.g., covered fully or partially by another window). The server encoded and transmitted the screen data and the client decoded and processed it, even though the video may be fully or partially invisible to the user, resulting in a waste of server, client, and network bandwidth resources. In various embodiments, to address this inefficiency, streaming of screen data can be adjusted based on the visibility conditions of the application window.

[0013] Different approaches can be utilized for adjusting screen data streaming based on window visibility. For example, when the window is minimized or fully obscured (e.g., fully covered another window, a lock screen, screen saver, another user interface (UI) element, etc.), the streaming of screen data can be discontinued (stopped or suspended). Because the video would not be visible in the GUI even if it was streamed to the client and processed, stopping video streaming in such cases can conserve resources without any impact on user experience. As used herein, the terms “stop”, “discontinue”, or “suspend” in reference to the transmission of the screen data are used interchangeably and broadly have the same meaning.

[0014] In other cases, such as when the window is partially obscured, the streaming can be adjusted to decrease resource consumption while continuing to stream the video. For example, the streaming of screen data may be adjusted by lowering the frame rate, decreasing the image quality, decreasing resolution, changing to different compression settings, or by any other approach that results in decreased consumption of server, client, and/or network resources. In such cases, because content quality may not be as important to the user when the window is only partially visible, resources can be conserved by adjusting the streaming while maintaining adequate quality for providing good user experience.

[0015] As a result, server, client, and network resources can be conserved while delivering a good user experience. The techniques can be implemented in various environments where encoded screen data is conveyed from a server to a client, such as video streaming, teleconferencing, remote application accessing, etc., and can be particularly advantageous in environments where servers experience high demand for screen content (e.g., video) from multiple clients under congested network conditions, such as in virtual desktop infrastructure (VDI) environments.

[0016] As used throughout this disclosure in the context of remote desktop environments, the terms, “desktop”, “remote desktop”, and “virtual desktop” are used interchangeably and refer to an instance of an operating system and/or applications that run(s) remotely with respect to the user. In a conventional VDI or DAAS environment, each virtual desktop corresponds to a virtual machine (VM) executed on a host server (i.e., a host computing device) that is physically located in a remote datacenter. Each host server may host any number of virtual machines (e.g., tens, hundreds, etc.) and each virtual machine may be owned by an individual user. The virtual machine typically includes a guest operating system (e.g., Windows) capable of executing applications for the user and the virtual machine is used to provide a virtual desktop for the individual user. The user who owns the virtual desktop can remotely log into his or her virtual desktop using a client device that establishes a network connection (e.g., Wide Area Network connection) with the host server and

remotely execute various applications on the virtual machine as if the desktop was running on the user's local client device. The client device can be any computing device capable of establishing a network connection, including but not limited to personal computers (PCs), laptops, mobile phones, tablet computers, wearable devices (e.g., smart watches, electronic smart glasses, etc.) or the like.

[0017] When a client device is accessing a remote desktop using a remote display protocol (e.g., RDP, PCOIP, VNC, etc.), the graphical user interface (GUI) of the desktop is generated on the server, the GUI image data is then encoded and transmitted over the network to the client device, where it is decoded and displayed to the user. For example, in one embodiment, the framebuffer pixel data on the server is encoded using a codec, such as H264, and transmitted over an Internet connection to the client, where the data is decoded and rendered on a local display screen to the user. Similarly, any user input information, such as keyboard and mouse events, is transmitted from the client device to the server over the network connection, where it may in turn cause various updates to the GUI of the remote desktop. In this manner, the user is able to view the GUI of the remote desktop and interact with it as if the desktop was actually running on the local client device, even though the desktop is actually executing remotely.

[0018] FIG. 1 illustrates an example of a virtual desktop environment, in accordance with various embodiments. The virtual desktop environment, such as VDI or DAAS environment, includes host servers (**102-1**, **102-2**, **102-N**) that are communicatively coupled with a number of client devices (**120-1**, **120-2**, **120-N**) via a network **106**. Network **106** may be a wide area network (WAN), or other form of remote communication link between the host servers (**102-1**, **102-2**, **102-N**) and client devices (**120-1**, **120-2**, **120-N**). Network **106** may further include numerous other components, such as one or more firewalls, connection brokers, management servers, etc., which are not shown here so as not to obscure salient features of the remote desktop environment. Host servers (**102-1**, **102-2**, **102-N**) may physically reside in a data center **101** of the enterprise (e.g., in case of VDI) or in a data center of a third-party service provider (e.g., in case of DAAS).

[0019] By way of illustration, host server **102-1** can interoperate with client devices (**120-1**, **120-2**, **120-N**) to provide virtual desktop services to users of client devices (**120-1**, **120-2**, **120-N**). For example, host server **102-1** can host, for each user, a desktop that is presented by a guest operating system (such as one of the guest operating systems **105-1**, **105-2**, **105-N**) running on a virtual machine (such as one of the virtual machines **110-1**, **110-2**, **110-N**) on host server **102-1**. In this context, the terms “desktop”, “remote desktop”, and “virtual desktop” refer to a computing environment in which a user can launch, interact with, and manage the user's applications, settings, and data. Each client device (**120-1**, **120-2**, **120-N**) can allow a user to view on a desktop graphical user interface (on a local display device) his/her desktop that is running remotely on host server **102-1**, as well as provide commands for controlling the desktop. In this manner, the users of client devices (e.g., **120-1**, **120-2**, **120-N**) can interact with the desktops hosted on host server **102-1** as if the desktops were executing locally on client devices (**120-1**, **120-2**, **120-N**).

[0020] In the embodiment of FIG. 1, host server **102-1** includes virtualization software **104** that supports the execution of one or more virtual machines (VMs) (e.g., **110-1**, **110-2**, **110-N**). The virtualization software **104** may be a hypervisor, a virtual machine manager (VMM) or other software that allows multiple virtual machines to share the physical resources of the server. In the illustrated embodiment, each virtual machine (e.g., **110-1**, **110-2**, **110-N**) can execute a guest operating system (e.g., **105-1**, **105-2**, **105-N**) that hosts a desktop for a single user at a time. For example, if five users connect to host server **102-1** for the purpose of initiating remote desktop sessions, the host server **102-1** can launch five VMs, each hosting one desktop for each one of the five users. These types of virtual desktop environments where user desktops are hosted within separate, server-side virtual machines are often referred to as virtual desktop infrastructure (VDI) or Desktop-as-a-Service (DAAS) environments.

[0021] In such virtual desktop environments, each client device (e.g., **120-1**, **120-2**, **120-N**) can

execute a virtual desktop client (e.g., **122-1**, **122-2**, **122-N**). For example, the virtual desktop client (e.g., **122-1**, **122-2**, **122-N**) can be a stand-alone, designated client application (“native client”), or a web browser (“web client”). In some cases, a standard web browser may be modified with a plugin to operate as a web client. The interaction between the virtual desktop and the client device can be facilitated by such a virtual desktop client (e.g., **122-1**, **122-2**, **122-N**) running in the OS (e.g., **121-1**, **121-2**, **121-N**) on the client device (e.g., **120-1**, **120-2**, **120-N**) which communicates with a server-side virtual desktop agent (e.g., **103-1**, **103-2**, **103-N**) that is running on the guest OS inside the virtual machine (e.g., **110-1**, **110-2**, **110-N**). In particular, the interaction can be performed by the virtual desktop agent transmitting encoded visual display information (e.g., framebuffer data) over the network to the virtual desktop client and the virtual desktop client in turn transmitting user input events (e.g., keyboard, mouse events) to the remote desktop agent.

[0022] It should be noted that the particular virtual desktop environment illustrated in FIG. **1** is shown purely for purposes of illustration and is not intended to be in any way inclusive or limiting to the embodiments that are described herein. For example, a typical enterprise VDI deployment would include many more host servers, which may be distributed over multiple data centers, which might include many other types of devices, such as switches, power supplies, cooling systems, environmental controls, and the like, which are not illustrated herein. Similarly, a single host server would typically host many more virtual machines than what is shown in this illustration. It will be apparent to one of ordinary skill in the art that the example shown in FIG. **1**, as well as all other figures in this disclosure have been simplified for ease of understanding and are not intended to be exhaustive or limiting to the scope of the invention.

[0023] FIG. **2** illustrates an example architecture of a system for adjusting streaming of screen data based on window visibility, in accordance with various embodiments. As illustrated in the example of FIG. **2**, a server **202**, which can physically reside in a data center, can be communicatively linked to a client device **204** via a network. The client device **204** can be a personal computer, laptop, smartphone, tablet, or any other applicable computing device that may be used by a user for consuming screen data. An agent **206** running on the server **202** can communicate with a client **208** running on the client device **204** for conveying the screen data. In various embodiments, the agent **206** can send encoded screen data to the client **208** and the client **208** can process the data to display it (e.g., display rendered frames) in a window of the client **208** (an application window) appearing in the client device GUI on a monitor **214**, which may be an integrated or an external monitor of the client device **204**.

[0024] In various embodiments, the agent **206** can be a virtual desktop agent running in a virtual desktop on the server **202**, as described above in the example of FIG. **1**. The client **208** can be a virtual desktop client running on the client device **204**, enabling a user of the client device **204** to access and interact with the virtual desktop executing on the server, as also further described in the example of FIG. **1** above. During the virtual desktop session, the agent **206** (the virtual desktop agent) can capture the GUI of the virtual desktop on the server and convey it to the client **208** (the virtual desktop client) as a data stream of encoded screen data, as illustrated in the example of FIG. **2**. The client **208** can decode and process the received encoded screen data to generate frames that can be displayed in a window of the virtual desktop client **208** appearing in the client device GUI on the monitor **214**. The virtual desktop GUI can thus be produced in the virtual desktop client window on the client device GUI and the user can view the virtual desktop and, for example, a video playing in it on the client device **204**.

[0025] In other embodiments, the system can be implemented in different environments (other than VDI). For example, the agent **206** can be any kind of application configured for sending screen data to the remote client device **204**, and the client **208** can be an application configured for rendering the screen data and displaying it to the user of the client device **204** on the monitor **214**. For example, the agent **206** and client **208** can be part of various products that implement screen data or video streaming, such as teleconferencing applications, remote application access applications,

remote computer access applications, video streaming service applications, etc.

[0026] In various embodiments, an encoder **210** can operate on the agent **206** for encoding the screen data, which can be a hardware or software encoder, before the screen data is conveyed to the client **208**. Some examples of encoders that might be used are H.264, JPG/PNG, H.265, MPEG-2, MPEG-4, among others. Generally, the encoded screen data can contain sequential frame data that has been encoded to facilitate transmission of the data. The encoded screen data can be received on the client device **204**, decoded by a decoder **212**, which can be a hardware or software decoder, and processed as necessary to render frames. Once a frame is rendered, it can be passed to and displayed on the monitor **214** in the client application window. For example, once a frame is rendered, the operating system (OS) of the client device **204** can be called to display the frame on the monitor **214**, e.g., the client **208** can make such a call to the client device **204** OS.

[0027] In various embodiments, the client **208** can contain a window tracker module **216**, which can collect various window information relating to visibility in the client device GUI of the client **208** window where the received screen data is displayed. The window information can include various information relating to visibility of the window in the GUI and/or information relating to events taking place on the client device **204** affecting visibility of the window in the client device GUI. As will be explained in further detail below, this information can indicate if the window is fully or partially obscured in the GUI, whether the window has been minimized, etc.

[0028] The window tracker **216** can convey the window information (and updates to the window information) to the agent **206**, where a decision module **218** can analyze the window information to determine how streaming should be adjusted. For example, based on the window information, the decision module **218** can determine that streaming should be stopped. In this case, the decision module **218** can produce a command or instruction for the agent **206** to stop encoding and/or conveying the screen data.

[0029] In other cases, based on the window information, the decision module **218** can determine that streaming should be modified in a particular manner (e.g., the encoding method should be modified). In this case, the decision module **218** can produce a corresponding command or instruction for the agent **206** to modify the streaming or the encoding method used to encode the screen data in the manner determined by the decision module **218**.

[0030] In various embodiments, the decision module **218** can apply various policies, algorithms, or rules, which may be defined by administrators, for determining how to change streaming based on the window information.

[0031] It should be noted that the system illustrated in FIG. 2 is provided only by way of example and alternative architectures are feasible without straying from the spirit of the invention. For example, in an embodiment, the decision module **218** may be located on the client device **204** instead of on the server **202** (e.g., It may also be part of the client **208**). In this case, the window information can be conveyed from the window tracker directly to the decision module on the client and the decision module can make the determination of whether and/or how to change the streaming. If the decision module determines that a change should be made, whether to stop streaming or modify it, it can send a corresponding message or instruction to the agent **206** instructing it to perform the corresponding change. In response to the message/instruction, the agent can then perform the corresponding change by stopping or modifying the screen data streaming, as the case may be.

[0032] In various embodiments, the window information can indicate that the window is minimized. For example, the window tracker **216** can observe operations and/or activities on the client device **204** (e.g., by hooking into or retrieving information from the OS) and detect when the window is minimized or when a minimize command is made (e.g., by the user). In various embodiments, the window tracker **216** can determine when the window has been minimized by analyzing the window region; for example, it can monitor the window region in the GUI and determine that it has been minimized when the region disappears or is fully reduced (with the client

208 is still running).

[0033] In various embodiments, the window information can indicate when the window is fully obscured, such as when the window is not minimized but is entirely invisible in the GUI. For example, the window may be fully obscured when it is completely covered/obscured by objects (e.g., other window(s) or UI objects) in the GUI, when the screen saver is active and covers the window, when the lock screen (also known as the “login” screen) is active and covers the window, or when the monitor is off. As applicable, the window tracker **216** can observe operations and/or activities on the client device **204** (e.g., by hooking into or retrieving information from the OS) to detect certain fully obscuring events (e.g., screen saver, lock screen, monitor off, etc.), or by monitoring the region of the window in the GUI to determine if it is obscured by other objects (such as windows or other UI objects).

[0034] For example, the window tracker **216** can determine if the window is obscured by other objects in the GUI based on the region of the window and on regions of other objects (e.g., other windows or UI objects) that are above the window in the GUI. To identify which objects are above the window, the window tracker **216** can analyze the Z-order or stacking order of the window and of other objects in the GUI. After identifying the objects that are above the window based on the order, the window tracker **216** can analyze the region of the window and the regions of any objects above the window to determine if the window is obscured by the objects above it. For example, if portions of the window's region are intersected by regions of any objects above it, then those intersected portions of the window can be determined to be obscured. If the entire region of the window is found to be obscured (i.e., intersected by regions of objects above it), then the window tracker can determine that the window is fully obscured. If some portion, but not all, of the window is found to be obscured (i.e., intersected by regions of objects above it), then the window tracker can determine that the window is partially obscured.

[0035] In various embodiments, if the window tracker determines that the window is partially obscured, it can further determine an obscuring proportion value for the window, which can also be part of the window information conveyed to the agent **206** and used by the decision module **218** to make streaming adjustment determinations. The obscuring proportion value can be a value such as a percentage, decimal, fraction, etc. corresponding to the proportion of the window's region that is obscured. For example, if a quarter of the window region is obscured, then the obscuring proportion value can be 25%, if one tenth of the region is obscured, the obscuring proportion value can be 10%.

[0036] When the decision module **218** receives the window information, it can implement various logic (which can be based in policies, algorithms, etc.) to determine how to adjust streaming based on the window information. For example, in some cases the decision module can determine that streaming and/or encoding should be completely stopped. In other cases the decision module can determine that the streaming should be modified (or the encoding method should be modified). In various embodiments, the encoding method can be modified in any of several ways that results in reduced use of resources, such as network resources (e.g., bandwidth) and/or processing resources such as CPU, GPU, RAM, etc. consumed by components in the system including the server **202** and/or the client device **204** for encoding, decoding, and otherwise sending and processing the data stream, as applicable.

[0037] For example, to modify the streaming or encoding, the frame rate can simply be reduced (e.g., from 30 fps to 10 fps), which can be a straightforward and reliable approach for modifying encoding and reducing resource consumption. Various other parameters of the streaming or encoding method can also be modified alone or in combination with others to make adjustments to the streaming, such as decreasing resolution, decreasing image quality, changing compression settings, changing encoders/decoders, and so on, any of which can also conserve processing and/or network resources. Hence, in various embodiments, the decision module **218** can make a determination based on the window information (using a policy, algorithms, etc.) to modify the

encoding method by performing one of or any combination of the following: decreasing the frame rate, decreasing the image quality, decreasing the resolution, changing compression (e.g., in a way that reduces resource consumption), changing encoders, etc.

[0038] In various embodiments, when the window is minimized or fully obscured (e.g., decision module **218** can receive a window information update indicating that the window is minimized or fully obscured), the streaming (and/or the encoding) can be completely stopped. Or, in some embodiments, the streaming can be reduced to some minimal level so that resources are maximally conserved.

[0039] In various embodiments, when the window is partially obscured (e.g., decision module **218** can receive a window information update indicating that the window is partially obscured), the streaming (and/or the encoding) can be modified instead of being stopped. It should be mentioned that in some embodiments the streaming may be stopped during partial obscuring (e.g., in some implementations where that may be desired or when the window is obscured beyond a certain threshold, e.g., 95%) but it may generally be preferable to adjust streaming instead of stopping it completely when the window is partially obscured.

[0040] For example, when the window is partially obscured, the streaming can be adjusted in certain ways as described above (e.g., decrease frame rate, quality, etc.) based on policy or logic. In various embodiments, the streaming can be adjusted based on the obscuring proportion value. For example, a policy or an algorithm can indicate at what obscuring proportion values certain adjustments (if any) should be made to the streaming. In various embodiments, the policy can identify thresholds for the obscuring proportion value so that certain prescribed modification to the encoding method are performed once the window's obscuring proportion value exceeds the threshold. Similarly, a policy can provide ranges of obscuring proportion values where the encoding method is to be modified in specific ways for each range. The policy can also provide formulas or algorithms that determine, based on the obscuring proportion value of the window, what modifications are to be made to the encoding method used to encode the screen data.

[0041] In an embodiment, the encoding method can be modified in a predetermined way only after a certain threshold obscuring proportion value is observed. For example, the system can have a policy or rule that a particular modification is to be performed (e.g., frame rate is dropped to 20 fps in a system where 30 fps is standard) after when window is more than 10% obscured. This way, the system will not start to change the encoding method and thereby affecting the content quality until the window is at least 10% obscured. Modification to other encoding parameters can likewise be performed based on threshold values being exceeded; frame rate is only being used here an example.

[0042] The policy can likewise contain multiple thresholds so that as the obscuring proportion value changes, the encoding method is likewise dynamically adjusted. For example, in addition to the above 10% threshold, the policy can indicate that another modification is performed (e.g., frame rate is dropped to 10 fps) after when window is more than 50% obscured, and that another modification is performed (e.g., frame rate is dropped to 5 fps) when window is more than 75% obscured. As mentioned, other approaches can likewise be implements using ranges of obscuring proportion value, formulas, etc. so that the encoding method can be dynamically adjusted based on different obscuring proportion values.

[0043] In various embodiments, after the system has adjusted the streaming due to the window being minimized or obscured, as described above, when the window becomes un-minimized (e.g., restored or maximized), or un-obscured, the adjustments can be reverted. For example, if streaming was stopped due to the window being minimized or fully obscured, once that condition is removed (e.g., user restores window after it is minimized, moves a window or UI object covering it, removes lock screen, etc.) and the window is no longer fully obscured, the window tracker **216** can send a window information update notifying the decision module **218** that the window is no longer minimized/fully obscured and the decision module **218** can instruct the agent **206** to restart

streaming. Similarly, after encoding is modified due to the window being partially obscured, once the window is no longer obscured, the window tracker **216** can send a corresponding window information update to notify the decision module **218** of the change and the decision module **218** can instruct the agent **206** to revert the encoding method to standard parameters.

[0044] FIG. **3** illustrates an example process flow for adjusting streaming of screen data based on window visibility, in accordance with various embodiments. The process can begin in operation **302** where a server can encode screen data using an encoding method and convey the encoded screen data to a client device. In various embodiments, an agent operating on the server can encode and transmit the data to a client operating on the client device. For example, in a VDI environment, the agent can be a virtual desktop agent in a virtual desktop executing on a server and the client can be a virtual desktop client running on a client device. In the VDI case, the encoded screen data sent by the agent to the client can convey the GUI of the virtual desktop. The example process of FIG. **3** can likewise be utilized in environments other than VDI for conveying different types of screen data from the server to the client device.

[0045] In operation **304**, the screen data can be decoded and rendered in an application window (e.g., a window produced by the client, such as a virtual desktop client) on the client device, in the client device GUI. In operation **306**, the system can detect that the window is minimized or obscured in the GUI. For example, a window tracker executing in the client can monitor window activity and/or the window region in the GUI and detect one of these events. If the event is a window minimized or fully obscured event, then the process can proceed to operation **308**, where the server can discontinue conveying screen data. For example, the window minimized/fully obscured event can be passed to and analyzed by a decision module, which can determine to stop the streaming and instruct the agent accordingly.

[0046] In operation **310**, the system can detect that the window minimized or fully obscured condition is removed (i.e., the window is no longer minimized or no longer fully obscured), and the process can return to operation **302**, where the agent continues streaming the screen data to the client.

[0047] If, in operation **306** it is detected that the window is partially obscured, then the process can proceed to operation **312**, where the system can calculate an obscuring proportion value. The process can then proceed to operation **314** where, based on the obscuring proportion value, it can determine if and how encoding should be modified. For example, the process can determine, using a policy and based on the obscuring proportion value, whether the encoding method should be modified and if so, how it should be modified (e.g., changing the frame rate). If it is determined that no modification is necessary, then the process can return to operation **302** where the screen data can continue to be streamed with the same parameters as previously. If, on the other hand, it is determined that the encoding method should be modified based on the policy, then the encoding method can be modified as indicated in the policy for the obscuring proportion value and the process can return to operation **302**, where the screen data can continue to be streamed, but now with the modified parameters.

[0048] FIG. **4** illustrates an example of some general components of a computing device, in accordance with various embodiments. In this particular example, the device includes one or more processors (e.g., central processing units (CPUs) **402** for executing instructions that can be stored in a storage medium component. The storage medium can include many types of memory, persistent data storage, or non-transitory computer-readable storage media. For example, the storage medium may take the form of random access memory (RAM) **401** storing program instructions for execution by the processor(s) **402**, a persistent storage (e.g., disk or SSD) **400**, a removable memory for sharing information with other devices and/or the like. The computing device typically can further comprise a display component **403**, such as a monitor, a touch screen, liquid crystal display (LCD), or the like. In various embodiments, the computing device will include at least one input device **405** able to receive conventional input from a user. This

conventional input can include, for example, a push button, touch pad, touch screen, wheel, joystick, keyboard, mouse, keypad, or any other such device or element whereby a user can input a command to the device. In some embodiments, the computing device can include a network interface component (NIC) **404** for communicating over various networks, such as a Wi-Fi®, Bluetooth®, RF, wired, or wireless communication systems. The device in many embodiments can communicate over a network, such as the Internet, and may be able to communicate with other devices connected to the same or other network.

[0049] Various embodiments described herein can be implemented in a wide variety of environments, which in some cases can include one or more user computers, computing devices, or processing devices which can be used to operate any of a number of applications. User or client devices can include any of a number of general purpose personal computers, such as desktop or laptop computers running a standard operating system, as well as cellular, wireless, and handheld devices running mobile software and capable of supporting a number of networking and messaging protocols. Such a system also can include a number of workstations running any of a variety of commercially-available operating systems and other known applications for purposes such as development and database management. These devices also can include other electronic devices, such as dummy terminals, thin-clients, gaming systems, and other devices capable of communicating via a network.

[0050] Many embodiments utilize at least one network that would be familiar to those skilled in the art for supporting communications using any of a variety of commercially-available protocols, such as TCP/IP, FTP, UDP or the like. The network can be, for example, a local area network, a wide-area network, a virtual private network, the Internet, an intranet, an extranet, a public switched telephone network, an infrared network, a wireless network, and any combination thereof.

[0051] The various environments in which the embodiments can be implemented may include a variety of data stores and other memory and storage media, as discussed above. These can reside in a variety of locations, such as on a storage medium local to one or more of the computers or remote from any or all of the computers across the network. In some embodiments, the information may reside in a storage-area network (“SAN”) familiar to those skilled in the art. Similarly, any necessary files for performing the functions attributed to the computers, servers, or other network devices may be stored locally and/or remotely, as appropriate. Where a system includes computerized devices, each such device can include hardware elements that may be electrically coupled via a bus, the elements including, for example, at least one central processing unit (CPU), at least one input device (e.g., a mouse, keyboard, controller, touch screen, or keypad), and at least one output device (e.g., a display device, printer, or speaker). Such a system may also include one or more storage devices, such as disk drives, optical storage devices, and solid-state storage devices such as random access memory (“RAM”) or read-only memory (“ROM”), as well as removable media devices, memory cards, flash cards, etc.

[0052] Such devices also can include a computer-readable storage media reader, a communications device (e.g., a modem, a network card (wireless or wired), an infrared communication device, etc.), and working memory as described above. The computer-readable storage media reader can be connected with, or configured to receive, a computer-readable storage medium, representing remote, local, fixed, and/or removable storage devices as well as storage media for temporarily and/or more permanently containing, storing, transmitting, and retrieving computer-readable information. The system and various devices also typically will include a number of software applications, modules, services, or other elements located within at least one working memory device, including an operating system and application programs, such as a client application or Web browser. It should be appreciated that alternate embodiments may have numerous variations from that described above. For example, customized hardware might also be used and/or particular elements might be implemented in hardware, software (including portable software, such as applets), or both. Further, connection to other computing devices such as network input/output

devices may be employed.

[0053] Storage media and computer readable media for containing code, or portions of code, can include any appropriate media known or used in the art, including storage media and communication media, such as but not limited to volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage and/or transmission of information such as computer readable instructions, data structures, program modules, or other data, including RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disk (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by a system device. Based on the disclosure and teachings provided herein, a person of ordinary skill in the art will appreciate other ways and/or methods to implement the various embodiments.

[0054] The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. It will, however, be evident that various modifications and changes may be made thereunto without departing from the broader spirit and scope of the invention as set forth in the claims.

Claims

1. (canceled)

2. A method comprising: establishing, on a server computing device, a virtual desktop session for a client computing device, wherein screen data of a user interface is encoded on the server computing device using an encoding method and streamed from the server computing device to the client computing device during the virtual desktop session and wherein the screen data is decoded and displayed in a window on the client computing device; receiving, at the server computing device from the client computing device, window visibility information collected on the client computing device, the window visibility information relating to the window displaying the screen data on the client computing device; determining, based on the window visibility information received at the server computing device, that the window displaying the screen data on the client device is partially or fully obscured; in response to determining that the window is fully obscured, suspending or discontinuing the streaming of the screen data from the server computing device to the client computing device; and in response to determining that the window is partially obscured, modifying the encoding method used to encode the screen data on the server computing device.

3. The method of claim 2, wherein modifying the encoding method comprises: modifying a frame rate of the screen data streamed from the server computing device to the client computing device.

4. The method of claim 3, wherein modifying the frame rate comprises: determining a proportion value corresponding to a percentage or fraction of the window that is obscured by one or more objects in the user interface; and adjusting the frame rate in accordance with the determined proportion value.

5. The method of claim 2, wherein modifying the encoding method is based on a policy on the server computing device, the policy containing one or more rules for controlling how to modify the encoding method based on the received window visibility information.

6. The method of claim 5, wherein the policy contains a first set of modifications to the encoding method associated with a first threshold for an obscuring proportion value of the window, and a second set of modifications to the encoding method associated with a second threshold for the obscuring proportion value of the window.

7. The method of claim 2, wherein modifying the encoding method comprises: decreasing resolution of the screen data, decreasing image quality of the screen data, modifying one or more compression settings of the encoding method, or changing an encoder used to encode the screen data.

- 8.** The method of claim 2, wherein the window visibility information is collected by a window tracker module on the client computing device, wherein the window tracker module retrieves, from an operating system of the client computing device, data corresponding to one or more of: a screen saver, a locked screen, operation of a monitor of the client computing, and a Z-order or stacking order of the window and one or more other objects in the user interface.
- 9.** A non-transitory computer readable storage medium having stored thereon program code executable by a computer system, the program code embodying a method comprising: establishing, on a server computing device, a virtual desktop session for a client computing device, wherein screen data of a user interface is encoded on the server computing device using an encoding method and streamed from the server computing device to the client computing device during the virtual desktop session and wherein the screen data is decoded and displayed in a window on the client computing device; receiving, at the server computing device from the client computing device, window visibility information collected on the client computing device, the window visibility information relating to the window displaying the screen data on the client computing device; determining, based on the window visibility information received at the server computing device, that the window displaying the screen data on the client device is partially or fully obscured; in response to determining that the window is fully obscured, suspending or discontinuing the streaming of the screen data from the server computing device to the client computing device; and in response to determining that the window is partially obscured, modifying the encoding method used to encode the screen data on the server computing device.
- 10.** The non-transitory computer readable storage medium of claim 9, wherein modifying the encoding method comprises: modifying a frame rate of the screen data streamed from the server computing device to the client computing device.
- 11.** The non-transitory computer readable storage medium of claim 10, wherein modifying the frame rate comprises: determining a proportion value corresponding to a percentage or fraction of the window that is obscured by one or more objects in the user interface; and adjusting the frame rate in accordance with the determined proportion value.
- 12.** The non-transitory computer readable storage medium of claim 9, wherein modifying the encoding method is based on a policy on the server computing device, the policy containing one or more rules for controlling how to modify the encoding method based on the received window visibility information.
- 13.** The non-transitory computer readable storage medium of claim 12, wherein the policy contains a first set of modifications to the encoding method associated with a first threshold for an obscuring proportion value of the window, and a second set of modifications to the encoding method associated with a second threshold for the obscuring proportion value of the window.
- 14.** The non-transitory computer readable storage medium of claim 9, wherein modifying the encoding method comprises: decreasing resolution of the screen data, decreasing image quality of the screen data, modifying one or more compression settings of the encoding method, or changing an encoder used to encode the screen data.
- 15.** The non-transitory computer readable storage medium of claim 9, wherein the window visibility information is collected by a window tracker module on the client computing device, wherein the window tracker module retrieves, from an operating system of the client computing device, data corresponding to one or more of: a screen saver, a locked screen, operation of a monitor of the client computing, and a Z-order or stacking order of the window and one or more other objects in the user interface.
- 16.** A computer system comprising: a processor, and a non-transitory computer readable medium having stored thereon program code that, when executed, causes the processor to: establish, on a server computing device, a virtual desktop session for a client computing device, wherein screen data of a user interface is encoded on the server computing device using an encoding method and streamed from the server computing device to the client computing device during the virtual

desktop session and wherein the screen data is decoded and displayed in a window on the client computing device; receive, at the server computing device from the client computing device, window visibility information collected on the client computing device, the window visibility information relating to the window displaying the screen data on the client computing device; determine, based on the window visibility information received at the server computing device, that the window displaying the screen data on the client device is partially or fully obscured; in response to determining that the window is fully obscured, suspend or discontinue the streaming of the screen data from the server computing device to the client computing device; and in response to determining that the window is partially obscured, modify the encoding method used to encode the screen data on the server computing device.

17. The computer system of claim 16, wherein modifying the encoding method comprises: modifying a frame rate of the screen data streamed from the server computing device to the client computing device.

18. The computer system of claim 17, wherein modifying the frame rate comprises: determining a proportion value corresponding to a percentage or fraction of the window that is obscured by one or more objects in the user interface; and adjusting the frame rate in accordance with the determined proportion value.

19. The computer system of claim 16, wherein modifying the encoding method is based on a policy on the server computing device, the policy containing one or more rules for controlling how to modify the encoding method based on the received window visibility information.

20. The computer system of claim 19, wherein the policy contains a first set of modifications to the encoding method associated with a first threshold for an obscuring proportion value of the window, and a second set of modifications to the encoding method associated with a second threshold for the obscuring proportion value of the window.

21. The computer system of claim 16, wherein modifying the encoding method comprises: decreasing resolution of the screen data, decreasing image quality of the screen data, modifying one or more compression settings of the encoding method, or changing an encoder used to encode the screen data.
