IBM

IBM Active Protection System Whitepaper

IBM Hard Drive Active Protection System

The IBM® Hard Drive Active Protection System helps to protect your hard disk drive when the shock sensor inside your ThinkPad® computer is enabled and detects some situations that could potentially cause damage to your hard disk drive. Difficulty with the hard disk drive often results from physical shock to the hard disk drive. One type of physical shock, called operating shock, occurs when the disk is in operation. During operation, the drive head is typically over the drive platters reading and writing data. When a physical shock to the drive occurs during operation, the head and the platters can come into contact causing both components to be damaged. The second type of shock, called non-operating shock, occurs when the head is in the unloaded position, or not positioned over the platters. When a physical shock occurs in the non-operating state, the head can contact the ramp it is positioned over and damage the ability of the head to read and write data to the hard disk drive. IBM has focused on two rating values for the amount of shock and vibration generally required to cause damage in each of these situations. The value for operating shock is 200G/2ms and the value for non-operating shock is 800G/1ms for a typical 2.5″ hard disk drive. These values suggest that by using this technology the hard disk drive is four times better able to withstand a shock, and hence more durable if the head is unloaded prior to receiving an excessive shock. The following information describes the design and implementation of this technology.

Note: The IBM Hard Drive Active Protection System protects only the primary hard disk drive on select ThinkPad computers using Microsoft® Windows® XP or Windows 2000. The protection system does not support protection of any secondary hard disk drives, including those installed in an UltraBay drive bay. The active protection system functions only with the 2.5″ hard disk drive provided by IBM due to special customization.

IBM Active Protection System Design

The active protection system works to minimize the risk that your hard drive could be damaged by moving the read/write heads of the hard disk drive to areas that do not contain data when the shock sensor detects computer tilt, vibration, or shock. There are two types of hard disk drives. The first spins down the motor after unloading the head. The second does not spin down the motor, but does unload the head. The hard disk drive is less vulnerable to damage when it is not in operation. Since the hard disk drive cannot be accessed while the head is unloaded, it may seem to the user that the drive has stopped. In reality, the disk access request has been temporarily suspended at the disk driver position so that the disk head can remain unloaded until a stable situation is detected. The suspended disk access request is then released and passed to the disk and the hard disk drive resumes normal operation.

The active protection system uses a combination of hardware and software components. The hardware component is a motion detector, or accelerometer, embedded in the motherboard which continually senses system orientation and movement. The software component receives and interprets signals from the accelerometer, differentiates between potentially harmful movements and repetitive motion, and signals the hard drive to stop when a potentially damaging event is predicted. The software component also includes a system tray icon and properties window.

Head unloading for increased hard disk drive shock tolerance

As a result of extensive testing with the computer lid both open and closed, IBM has found that in typical drop accidents either from the knee or a desk to a concrete floor, the internal hard disk drive is protected by the durable ThinkPad shell so that the received shock level to the hard disk drive generally does not exceed 800G or 800 times the force of gravity. Since 800G is the maximum rating of shock tolerance of the hard disk drive with the head unloaded, the hard disk drive can be better protected during most of these common accidents in typical usage if the disk head is unloaded prior to receiving the shock impact. Head unloading can take 300 to 500ms, and the average duration after detecting a free-fall situation is 300ms. Therefore, it is too late to start head unloading after detecting the free-fall situation. This makes it necessary to concentrate on the behavior of the machine prior to a drop. The initial behavior acts as a prediction of the impending accident. In general, the duration of the predicting event is much longer than the actual free-fall. This enables the active protection system to respond to the impending accident prior to receiving the shock. The machine posture or system orientation is constantly checked by monitoring acceleration and using a prediction algorithm to statistically analyze recent behavior in typical usage. Head unloading is initiated by degrees of tilt, acceleration, or shock. The degrees at which head unloading occurs are adjusted and fine-tuned every time a proper prediction is applied for the current motion. The disk drive head remains unloaded until detecting a stable environment for approximately one to four seconds depending upon the amount of excessive acceleration at the beginning of the current shock or posture change.

Use of Prediction Algorithm

The active protection system employs a heuristic learning algorithm to track system orientation. The Shock Manager, a system thread created by the Shockprf.sys of a kernel mode device driver, analyzes the variations in acceleration and collects system orientation data into the Shock History Database. The collected data is then used to tune sensitivity and predict excessive shocks. This tuning is important in minimizing the disk performance penalty caused by prediction failures. Once the Shock Manager detects a certain variation which may be equivalent to one usually seen just before receiving an excessive shock, the Shock Manager acts immediately to stop the hard disk drive.

The sensitivity to predict a shock varies depending on usage conditions. In general, the more stable the ThinkPad computer stays, the more sensitively the Shock Manager behaves. The Shock Manager focuses its attention on the current acceleration variation and the weighted average in the recent past. The log is used to minimize intrusive operation during normal usage of the computer. If the hard disk drive head is unloaded after detecting a potentially harmful situation, the user can shorten the current head-unloading period up to 1 second on the condition that a calm state, stable enough to remove the risk of a drop, continues for at least one second and at the same time mouse movement activity for more than 200ms is detected thereby informing the active protection system that this is not a drop situation.

The design of the active protection system allows for certain shocks or vibrations that fall within a span of accepted or normal motion and does not repeatedly stop the hard drive when this level of motion is detected. You can select a checkbox in the properties window to temporarily disable hard drive protection while repetitive motion or vibration is detected. This feature is particularly useful when

the ThinkPad computer is used on a plane or train and repetitive vibration is expected.
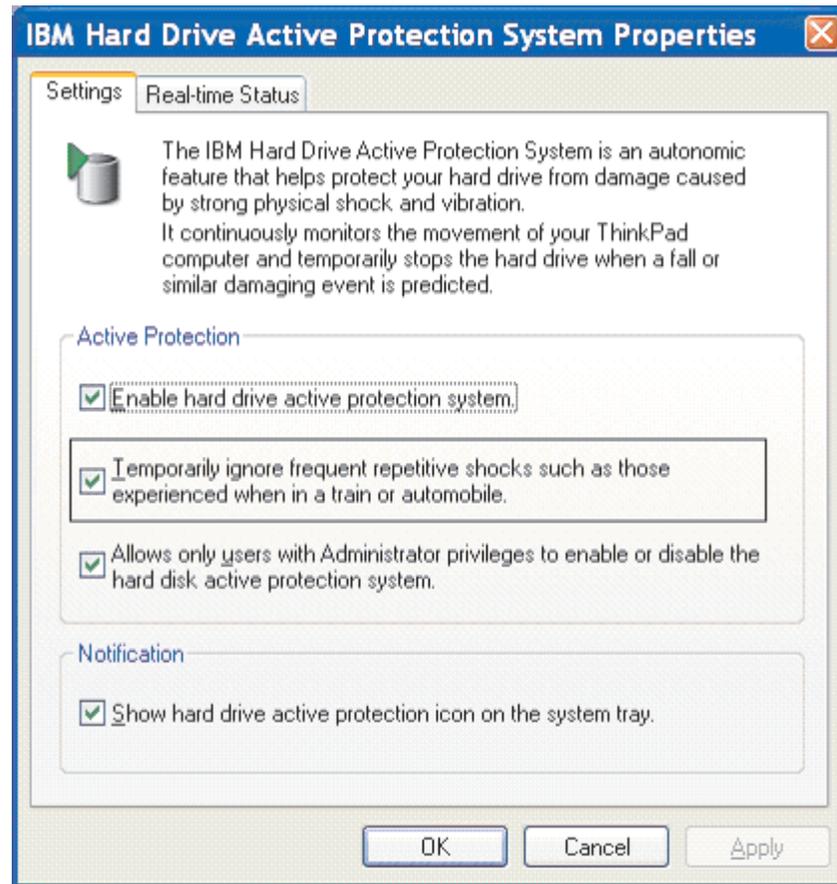

Figure 1. IBM Hard Drive Active Protection System Properties

Application function overview

The APS software monitors the accelerometer sensor information and displays the sensor status in the system task tray. The following four states of system status are illustrated using the system tray icon:

- Shock sensor is disabled. In this state, shock sensor monitoring is not enabled and hard drive active protection is not activated.

Figure 2.

- Shock sensor is enabled, but no shock is detected. In this state, shock sensing is enabled and monitoring the shock condition. The active protection system does not detect any shock condition and the internal primary hard disk drive is operating normally.

Figure 3.

- Shock sensor is enabled and the head of the primary hard disk drive is unloaded due to shock condition. In this state, the computer has detected the shock condition and the head of the primary hard disk drive is unloaded to protect the hard disk drive from physical damage.

Figure 4.

- Shock sensor is set to temporarily ignore frequent repetitive shocks such as those experienced when in a train or automobile.

Figure 5.

User interface and task tray applet

The active protection system application program is installed as part of the IBM Hard Drive Active Protection System driver package on Windows 2000 and Windows XP platforms using InstallShield version 6.3. Once this package is installed, an icon is added to the system tray in response to detecting an excessive shock. The user can remove the system tray icon by right-clicking in the system tray and selecting **Remove Hard Drive Active Protection icon from the System Tray** or by clearing the **Show hard drive active protection icon in the system tray** checkbox. InstallShield installs the following components:

- ShockPrf.sys: kernel mode device driver for prediction algorithm and hard disk drive control
- Shockmgr.sys: kernel mode driver for miscellaneous operation
- Sensor.dll: application interface dll
- TpShCPL.cpl: control applet
- TpShocks.exe: task tray application
- TpShCPL.dll: bitmap resource file for this application program
- TpShPrm.hta: promotion pop-up window
- TpShPrm.gif: animation for promotion pop-up window
- TpShPrm.jpg: banner picture for promotion pop-up window

Use the task tray menu to enable and disable the active protection system. Select Enable Hard Drive Active Protection on the system task tray to enable the shock detection and protect the primary hard disk drive from damage. To see the list of options for the protection system, double-click the icon in the system tray, click **Start --> All Programs --> Access IBM --> IBM Hard Drive Active Protection**, or open the Control Panel and double-click **IBM Hard Drive Protection**. The properties window is displayed:
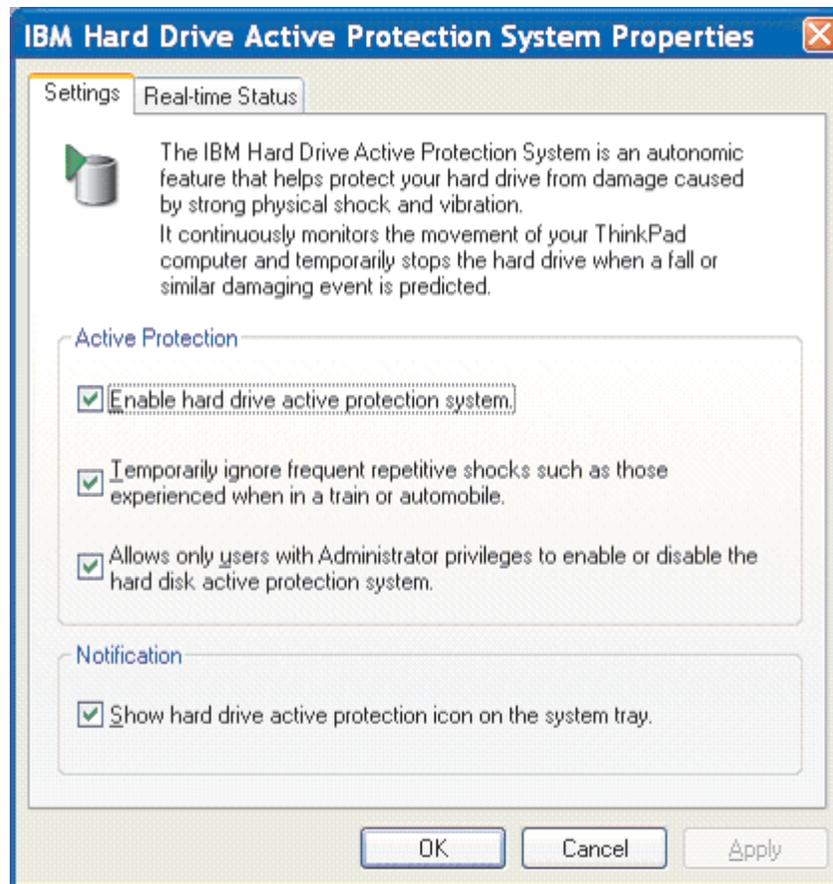
Figure 6. IBM Hard Drive Active Protection System Properties

Description of active protection system options

You can use the following list of options to customize the active protection system. Each of these options is available on the properties dialog box.

- Enable hard drive active protection system checkbox: If this checkbox is selected, the IBM Hard Drive Active Protection System is enabled. If a shock is detected, the computer stops the hard disk drive operation to protect the drive from physical damage. The default setting is enabled.

- Temporarily ignore frequent repetitive shocks checkbox: Select this option to avoid frequent stops of the hard drive when you use the computer in an environment where the shock sensor is likely to detect repetitive, low-level shocks, such as those experienced when riding on a train or airplane. If enabled, this option functions when the ratio of the duration of stopping the hard disk drive caused by the protection system responding to low-level shocks exceeds a specific percentage within a certain amount of time. Once the shock sensor detects a stable environment for an extended amount of time, this option resets so that the sensitivity for received shocks returns to normal. In all cases, the protection system stops the hard disk when heavy shocks are detected.

- Allow only users with Administrator privileges to enable or disable the hard disk active protection system checkbox: If this checkbox is selected, you must have Administrator privileges to enable or disable the active protection system.

- Show hard drive active protection icon on the system tray checkbox: If the checkbox is selected, the icon showing the status of the shock sensor is displayed in the system tray. The active protection system is enabled by default whenever the computer is operating. It is automatically disabled while the computer is:
  - Loading the operating system
  - Enter Standby or hibernation mode
  - Resuming normal operation after being in Standby or hibernation mode
  - Being shut down
  - Turned off

Important features of the IBM Active Protection System

Enable/Disable feature (user option via utility): User can manually enable and disable the active protection system using the software user interface.

Automatic ignore feature: Sometimes the user is in an environment that has associated vibration (such as in a car or airplane where the entire vehicle vibrates). In these environments, the vibration may be transmitted to the ThinkPad computer. The Automatic Ignore feature is helpful in this situation. This feature is enabled by default, but the user can manually change choice at any time via the software utility.

Cancel feature for impulse-type vibration: This feature cannot be manually controlled by the user. The Shock Manager ignores impulse-type acceleration change so as to minimize prediction failures. An adaptive low-pass filter function inside the Shock Manager performs this function.

Heuristic sensitivity tuning feature: This feature cannot be manually controlled by the user. The sensitivity for shock prediction is dynamically changed depending on body posture change with received shocks, vibrations and user input activities.

Administrative lock: This feature restricts users without Administrative system rights from changing the Active Protection System properties.

Summary

The IBM Hard Drive Active Protection System can greatly improve overall system reliability by providing enhanced hard drive protection from shock. Using the latest technology to constantly monitor the movement of your ThinkPad computer, users can feel confident that their data will be better protected in the event of a drop or similar potentially damaging event.

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