Nightscout FDA presubmission

Release 0.0.1

Nightscout contributors

July 09, 2014

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ONE

COVER LETTER

1.1 a. Cover Letter

To whom it may concern, Dr. Stayce Beck, et al.

This presubmission is to discuss open source projects and FDA oversight. Specifically, this is to discuss the Nightscout project, aka "CGM in the Cloud."

The sponsor, collectively known as Nightscout contributors, may be contacted through one of the core developers:

> Ben West 4521 17th St. Apt 5 San Francisco, CA 94114

Additionally, core contributors openly discuss administration of the project via an email list administered by Google groups:

- https://groups.google.com/forum/?utm_medium=email&utm_source=footer#!forum/nightscout-core-dev
- nightscout-core-dev@googlegroups.com

1.1.1 Pre-Sub for Nightscout

To whom it may concern, Dr. Stayce Beck, et al.

For CDRH submissions, the addressee may be the appropriate branch or branch chief if the applicant knows where the subject device or similar devices are reviewed. For CBER submissions, the addressee may be the appropriate Office Director or Regulatory Project Manager where the subject device or similar devices are reviewed. The cover letter should

> http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/CDRH/CDRHReports/ucm279288.htm 24 CDRH Premarket Review Submission Cover Sheet available at
>
> http://www.fda.gov/downloads/AboutFDA/ReportsManualsForms/Forms/UCM080872.pdf Contains Nonbinding Recommendations

contain complete contact information (i.e., the company name, address, contact person, phone number, fax number, and email address). In addition to describing the reason for the submission in the reference line, the cover letter should also clearly identify the name of the device and include the signature of the contact person, or other responsible party.

CHAPTER

TWO

NIGHTSCOUT

Nightscout is a suite of open source projects. A smartphone provides ubiquitous network connectivity to Dexcom's wireless receiver. After a polling period the last reading from the Dexcom reciever is transmitted to a database on the internet. A website renders near-real-time views of the records stored in that database. Additionally, the website offers an http endpoint that a pebble watch can use to display the last known alarm status, trend, and glucose level as reported by the Dexcom receiver.

2.1 Device Description

2.1.1 Nightscout project

The Nightscout project is actually a suite of several independent projects:

- dexcom-uploder - Android app to poll dexcom, upload to cloud
- cgm-remote-monitor - A node.js web application that displays values stored by the Dexcom.
- cgm-pebble - A pebble watchface that reads and displays values from cgm-remote-monitor.

When assembled, the completed device is called a "Nightscout rig." In addition to the raw source code for these applications, other community maintained resources exist to help people learn how to assemble their own rigs. These include groups, photos, shared documents, videos on a variety of social media, including a centralized community curated website for documentation as well as community maintained forum software.

cgm-remote-monitor

This is a web app which simulates the display of a Dexcom receiver. In addition to showing the last known glucose level, it displays when the reading was taken, and offers a way to pan several hours retrospectively.

Every 5 minutes, a node.js server polls a mongo database, emitting the last readings over the last two days to any listeners subscribed to the server's "sgv" websocket event. The server also serves a combination of html, css, and javascript to simulate a near-real-time display of the Dexcom receiver.

The web display works on most modern web browsers.

dexcom-uploader

dexcom-uploader is an Android application implemented in java. The application starts when a Dexcom receiver is detected using the operating system's usb management system. The application reads data from the serial port made available by Dexcom's usb connection, and uploads the latest record to a specified data backend. The backend may either be a RESTful API or a mongo db, and is configured using a preferences panel inthe application.

The *dexcom-uploader* source code must be compiled and distributed as an APK before it can run on an Android smartphone. Once installed and configured to upload data to the preferred cloud "backend", a USB OTG cable is used to connect the smartphone to the Dexcom receiver's micro usb port. The Dexcom receiver is a device cleared by the FDA for continuously monitoring glucose levels sampled from interstitial fluid. The receiver is designed to store and display values transmitted by the Dexcom sensor. *dexcom-uploader* uses the serial connection provided by this usb capability to exchange data with the Dexcom receiver. The behavior of the uploader has been designed to behave as Dexcom would expect any data management system to behave. There is no expected difference in Dexcom's behavior when the uploader smartphone is attached or while our software is auditing the records on the Dexcom receiver.

cgm-pebble

cgm-pebble is a C and javascript watchface developed using PebbleSDK. The javascript code runs on a Smartphone maintaining bluetooth connectivity to the Pebble watch. The javascript code retrieves information from *cgm-remote-monitor* and sends the last reading to over bluetooth to the pebble watch. The C code runs on the watch, receiving messages over bluetooth from a smarthphone, and rendering the date, time, value, and trend as reported by a running instance of *cgm-remote-monitor*.

2.1.2 Development

Development takes place using github, from the nightscout organization page: https://github.com/nightscout/. Modifications, upgrades, development, and issue tracking happen using the resources connected to assets shared by a community of people. Each and every change to the source code is tracked by git and discussed through a github pull request. Upgrades are provided by providing git merge requests, often using the Github UI, by identifying the last commit hash in use, and a verified change controlled path to apply latest updates from trusted contributors.

2.1.3 Assembly and guides

The git repos merely provide the source code, and a verified way of exchanging source code for these projects. In order to be used, the source code must be configured, compiled, deployed, and installed.

While each repo contains instructions on how to test and work with that repo, the Nightscout guides, forums, youtube videos, pictures, and Facebook group provide "educational" material on how people have combined and configured these disparate parts to assemble something resembling a "medical device." The web guides also reside in a git repo, where improvements are proposed by the community, reviewed, and adopted in similar manner to the source code itself.

The guides explain how to configure and install each component, with warnings of "things that might go wrong" at each phase. When people experience issues following the guides or during use, they use social media to find people that have similar issues or ask for help. There are also recommendations, optimized for cost and predictability, on which service providers are available, as well as how to work with those service providers.

2.1.4 c. Device Description

Please provide sufficient information regarding the device description, 25 which may include:

- pictures of the device (where applicable);
- engineering drawings (where applicable);
- physical, chemical and/or biological processes/principles used by the device to generate device output, if applicable;
- physical and biological characteristics of the device output, if applicable;

- samples to demonstrate the use of the device (where feasible and appropriate);
- explanation of the user interface and/or how the device interacts with other devices or with the user (medical professional and/or patient);
- explanation of the materials used in the device;
- a brief explanation of how the device is manufactured (where necessary);
- discussion of the mechanism of action and how the device and/or, if applicable, device output is used;
- for an IVD, detailed technical description of your device including instruments, reagents, components, software, principles of operation, and accessories (if there are changes to a previously cleared or approved device, then you should describe these changes);
- discussion of the scientific basis for development of the device or an explanation of expected clinical utility; and
- for a device to be submitted in a 510(k), any anticipated predicate and a descriptive comparison of the device to the predicate device.

In addition to pictures and a written description, other information about the clinical use of the device, such as a surgical technique guide or video of how the device is used in the clinical setting, may be helpful.26

CHAPTER

THREE

PROPOSED USE

3.1 Nightscout

Nightscout is intended to be used as part of a data management system. The system provides for a "glanceable" secondary display of the information originating from the Dexcom CGM. A website allows the display to be presented on any device which can display websites to duplicate the display of the Dexcom.

3.1.1 Single pane of glass

The website url is typically shared with caregivers and interested parties. This allows multiple people to monitor a Dexcom user's glucose levels from concurrently from any internet connection. Multiple redundant displays eliminates transcription error and raises the fidelity of communicating current therapy status.

3.1.2 Glanceability

Displays are duplicated in multiple redundant locations. This alleviates people from needing to physically locate and attend to the receiver. The lowered burden enables people to be more persistently aware, and therefore respond to scenarios with treatment with greater ease.

For example, in scenarios where no therapeutic action is required, but the glucose levels must be considered, the glanceable display eliminates the 30 second interuption to an existing workflow.

Reliance on pre-existing work

The Nightscout project relies on commodity components, as well as the excellent work from the folks at Dexcom. The android software interacting with the Dexcom receiver attempts to faithfully transmit data from the receiver to a configured storage/data management service hosted on the internet. The android software is agnostic of the data management service, and can be configured to work with several different data management service providers. It also attempts to behave in the way that Dexcom expects all data management systems to behave. An open analysis of the source code listings and comparisons of behavior reveals that the behavior of the Dexcom receiver is unaffected when this system is in use. The use or non-use of Nightscout has no observable difference in the Dexcom equipment or system, either while Dexcom is in use or after. Eg, we believe that Nightscout has no effect on Dexcom's performance, quality, or safety.

When Nightscout is in use, the community recommends that users maintain their normal therapy. Nightscout should not alter therapy plans or decisions. Many of the community members recommend falling back to baby monitors, phone, sms, smbg finger-sticks, and physically checking the Dexcom receiver as tools to augment therapy, even while Nightscout is in use. The guiding philosophy behind this advice is that technology is a tool for managing therapy; that people administer therapy, not technology. Nightscout is another tool using commonly available technology, like

baby-monitors, to bring diabetes therapy, specifically communicating current satus of therapy, more in line with the way the users of these tools, like Dexcom, feel is acceptable.

Uses of Nightscout

Nightscout is useful any time remote near-real-time monitoring of Dexcom readings are desirable. People with diabetes find it useful to keep mindfulness of glucose levels while biking or other activities requiring both hands. People with diabetes find it useful for sharing and gaining empathy of their glycaemic states.

Due to the ease of use, parents have been able to co-ordinate with school Nurse to prevent or treat injuries which are otherwise common. In some cases, use of Nightscout has helped gain insight into how common these injuries are, and we believe that the community aggregator can be used to report these injuries to the FDA for increased oversight of Dexcom and Medtronic devices in the marketplace. The community has also received reports of some parents using Nightscout to co-ordinate sleep-overs or camp visits, and in some cases walks with Grandpa, many for the first time, that would not other wise happen. They all cite Nightscout's remote telemetry in liberating these activities, in some cases with pictures indicating injuries staved off or critical rescue care co-ordinated.

Adult users have cited Nightscout in increasing discretion. A common complaint among users of type 1 diabetes medical equipment is that the mandated use of the equipment combined with the time it takes to use the equipment often presents the unknowing public with a rude experience. It often appears that a PWD is ignoring someone by favoring a phone or pager or just producing rude beeps. When Nightscout is in use, the requirement to touch one of these medical devices disappears, which allows incorporating mindfulness more often and in a variety of different ways into the every day work flow. As a result, fewer interuptions from physically touching the medical device increases discretion because social disruptions are also reduced.

Requirements

3.1.3 Nightscout uploader device

Android smartphone capable of "USB OTG" capability. These are commonly available. WIFI only versions, known as "android mini-pcs" or and "Android TV box" are also commonly available. The prices vary widely from vendor to vendor, and depending on the cell network carrier subsidies.

Without any help, the DIY version requires downloading the source code from the internet. Google's Android software development kit is required to configure and compile the source listings from the git repo. This process requires that users know, or learn how to, prepare their device for debugging, go through basic debugging steps in order to configure, compile, and deploy the software as binary android package, and then install and run the software on their own smartphone.

d. Proposed Intended Use/Indications for Use

Please provide sufficient information regarding the proposed intended use/indications for use,

which may include:

- identification of the disease or condition the device is indicated to prevent, mitigate, screen, monitor, treat, or diagnose;
- identification of the target population;
- part of the body or type of tissue to which applied or with which the device is interacting;
- frequency of use;
- physiological use; and
- statement of whether the device is intended for prescription and/or over-the-counter use.

For an IVD device, this information should include a detailed draft of the intended use of the device including the intended use population, the analyte/condition to detect, and the assay methodology (see Section F of Appendix 1 for more detailed information).

CHAPTER

FOUR

PREVIOUS WORK

4.1 e. Previous Discussions or Submissions

Please summarize any previous discussions with/submissions to (including submission numbers) the agency on this or a similar device (e.g., previous discussions on a prior device design), including submission numbers as appropriate.

CHAPTER

FIVE

OVERVIEW OF PRODUCT DEVELOPMENT

5.1 Community based, social technical development

5.1.1 Nightscout begins

As an open source project, the entire source code came into existence when people affected by type 1 diabetes with access to the best and safest therapy options found themselves unable to obtain therapy without any adverse events. In order to help monitor, communicate, and understand therapy, a few individuals created a data management system using commodity equipment allowing them to easily monitor the CGM without requiring physical access to the CGM receiver. Spurred by the improved family relationships and finding therapy easier to track, communicate, and manage, more and more people have added small improvements or helped others to gain liberties on their own. Many of these individuals cite "keeping their own children safe" as reasons for beginning their involvement with the project.

As of July 1, 2014, a dozen or so like-minded individuals record all proposed changes in their own Github forks or Github branches dedicated to discussing improvements or changes to a code base that is in active use by several dozen individuals and families. After the community reviews and tests these proposals in a public audit called a "pull request," one of the core contributors accepts the changes into the "master" branch. This workflow is sometimes called "gitflow" http://nvie.com/posts/a-successful-git-branching-model/.

After the "master" branch has updated with changes relevant to the community, specially crafted pull requests allow tracking the exact git deltas necessary to bring another repo up to date with the community accepted versions. When community members report bugs, this tracking system allows developers to reproduce and co-ordinate fixes, in some cases specifically tailored to members' needs.

For example, in one instance, a mom from outside the U.S. needed displays in mmol/l vs mg/dl. A group of interested members teamed up to work on special mmol/l versions. The member actually completed the required changes, sharing the needed deltas with the group. As a result, we were able to re-use these same git tracking methods to compare and issue updates specifically for these users needing mmol/l.

5.1.2 Open source methodology

The development of Nightscout as an open source project follows a predictable development pattern to identify issues, incorporate bug fixes, as well as develop new features. The model, as discussed by Gabriel Coleman in Coding Freedom, http://codingfreedom.com/ relies heavily on an open review process to share and distribute improvements.

The Software Freedom Law Center http://www.softwarefreedom.org/resources/2010/transparent-medical-devices.pdf

5.1.3 Known issues

There are several proposed improvements and known issues. Notably, the system as-is is not HIPAA compliant. One of the key features in this system that has helped to liberate people, and thus make them safer, is the ease of use

that accompanies pubically accessible data. While we will adopt optional controls for authorizing and accessing data, parents of this system value easily sharing data with a school nurse with minimum hassle.

5.2 Future plans

The sponsors would like to discuss appropriate regulatory controls that protect open source authors' free speech as well as provides FDA with an appropriate framework to fulfill their mission.

5.2.1 Oversight

Given the community's frustration with safety in available medical devices to manage type 1 diabetes therapy, we believe there are opportunities for open source authors and FDA to work together. One such opportunity is in post-market surveillance. We have developed an aggregator which re-displays de-personalized many Nightscout remote monitors in a single "spaghetti plot." We propose modifying this aggregator to automatically compile and submit reports to the FDA in order to aide in post market surveillance of devices used in diabetes therapy.

5.2.2 Integration

In the interest of safety, we need a single display to contextually manage type 1 diabetes. We will add data transfer from Medtronic insulin pumps to obtain "treatment" data consisting of the bolus wizard and bolus records. Additionally, the display will automatically show both the treatment data, carbohydrates, insulin, and carb ration, from the insulin pump overlaid with glucose readings from the Dexcom CGM.

In addition, we will also explore integrating with many other health, fitness, and nutrition APIs.

We will follow up with additional pre-subs if required to discuss further development efforts.

Instructions

Please provide an overview of the product development, including an outline of nonclinical and clinical testing either planned or already completed. However, please note that our review of a Pre-Sub will not include a review of bench or clinical data that you have already collected.

If you intend to include complete copies of literature articles as part of this section, please try to include only those that are relevant to the questions you are asking. Additional articles can be provided in any subsequent marketing application or IDE.

CHAPTER

SIX

SPECIFIC QUESTIONS

- Is this a secondary or passive or active display?
- What does distributing mean?
- What is the medical device? There are 6 separate open source projects, including this pre-sub and the forums, all with separate maintainers and contributors. An assembled rig without the "cloud services" up and running does nothing.
- If listing source code on the internet is widely considered "free speech" how does this relate to "distributing free speech?"
- Is there an API to upload data, relating to injuries or just for all therapy, to the FDA in order to aide in post-market surveillance?
  - Is there a way to prepare some kind of surveillance report, or observations of things we have found to the FDA outside of formal PMA/510k?
    - Should we build a "report to FDA" button into our UI to aide surveillance?
- Should we develop a risk assessment framework for Nightscout?
- Can we work on some framework to provide FDA with oversight for open source projects like Nightscout.
- How would this project be categorized, pending http://blogs.fda.gov/fdavoice/index.php/2014/06/fda-encourages-medical-device-data-system-innovation/

6.1 g. Specific Questions

The Pre-Sub should include specific questions regarding review issues relevant to a planned IDE, or marketing application (e.g., questions regarding pre-clinical and clinical testing protocols or data requirements) as our advice will be guided by your questions and may not identify all submission requirements. Appendix 1 of this guidance contains sections specific to IDE, 510(k), PMA, and HDE that list examples of questions appropriate to each submission and application type.

CHAPTER

SEVEN

FEEDBACK

7.1 h. Method for Feedback

You should specify how you prefer FDA to provide the feedback you are seeking. You may request our feedback through an in-person meeting, a teleconference, facsimile, or by email. Please note that FDA will ultimately decide the means of communicating the feedback, but will consider the desired method requested in the Pre-Sub. If FDA has already agreed to a meeting, it is the sponsor's decision regarding whether this previously scheduled meeting should occur even if FDA has provided a written response to the sponsor's questions. If we provide feedback through a meeting or teleconference, the final meeting minutes will be considered FDA's formal written feedback (see Section IV.D. below).

If you are requesting a meeting or teleconference as the method for feedback, your submission should include:

- the meeting format you are requesting (i.e., in-person or by teleconference);
- three (3) or more preferred dates and times when you are available to meet using the guidelines in Table 1 above for scheduling;
- the planned attendees, including each attendee's position, or title, and affiliation. If you have not yet identified all of your attendees, you should indicate the type of subject matter experts you plan to invite so that we can ensure appropriate FDA experts are in attendance. Please note foreign visitors meeting in an FDA facility require advanced security clearance. See Section IV. B. "Security Screening" below for additional information on how to request security clearance for Foreign Nationals; and
- a list of any audiovisual equipment you will need, such as conference phone or LCD projector.

You should propose the duration of the meeting you are requesting. In our experience, one (1) hour is adequate for most meetings. If you believe that more than one (1) hour is needed, please provide a rationale for the duration you propose. You should also refer to the rationale and confirm the duration requested when the division contact person schedules your meeting.

We recommend that your agenda allocate the last ten (10) minutes of the meeting for summarizing the discussions and any next steps or action items.

CHAPTER

EIGHT

ABOUT

In open source fashion, this document's raw source, pdf version and an html rendering is available online. The purpose is to create a framework for having a discussion with the FDA.

CHAPTER

NINE

INDICES AND TABLES

- *genindex*
- *modindex*
- *search*