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Authors: P. Andersson, Cisco Systems; J. Lindblad, Cisco Systems; S. Mitrovic, Cisco Systems; M. Palmero, Cisco Systems; E. Roure, Cisco Systems; G. Salgueiro, Cisco Systems; E. Stephan, Orange

Sustainability Insights

Abstract

This document motivates the collection and aggregation of sustainability environmental related metrics. It describes the motivation and requirements to collect asset centric metrics including but not limited to power consumption and energy efficiency, circular economy properties, and more general metrics useful in environmental impact analysis. It provides foundations for building an industry-wide, open-source framework for the reduction of greenhouse gas emissions, enabling measurement and optimization of the overall impact on the environment of networking devices, software applications, services, and solutions across the lifecycle journey.

Status of This Memo

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1. Introduction

To answer questions about how sustainable equipment and operational practices are, various key performance indicators (KPIs) produced by network devices, management systems, and networking solutions are necessary. While such KPIs are abundantly produced and collected today there are quite a few issues with their usability and commonality. Without a common definition of metrics across the industry and widespread adoption, we will be left with ill-defined, potentially redundant, and proprietary metrics.

An aspect lacking today is the precise definitions of the collected metrics. This leads to KPIs that are not comparable to each other, as it is unknown what is included in the outcomes and what is not. It makes it challenging to sum or compare numbers from different manufacturers and organizations without investing in data normalization and a high number of assumptions.

To produce aggregate data, it is also important to consider how the component inputs are combined. Different vendors and operators might do this aggregation differently, yet again producing values that are hard to combine or compare when also using different units of measurement. In many cases, one might suspect the actual numbers are underestimated, since there is competitive pressure to produce small numbers to report on the environmental impact of Internet communications and applications in contrast with the benefit of using it. The aim shall not be to "produce the numbers" but to find quantitative measures, when possible, that give a fair assessment of Sustainability related metrics vs. useful work.

It may be tempting to define the useful work in networking equipment as simply as the number of bits that are passing through the device. For some types of equipment, that might be appropriate, but clearly a video system that is sending a video stream with better video compression is not necessarily less sustainable just because it sends fewer bits per Joule. There are also many kinds of networking equipment where measuring the end user value in number of passed bits is obviously ridiculous, and other metrics have to be defined. Monitoring or management systems are examples of this.

Another important and key aspect, when referring to environmental impact metrics is what needs to be considered as part of the lifecycle. Life cycle assessment, also known as LCA, of networks and services, is defined by ISO 14040 as the compilation and evaluation of the inputs, outputs, and potential environmental impacts throughout its lifecycle.

LCA is based on four main phases:

*Goal and Scope

*Inventory Analysis

*Impact Assessment

*Interpretation

This document is setting up the stage to identify data quality requirements, under the information and communications technology (ICT) category. Following product Lifecycle Accounting (LCA), this document focuses on using the five product lifecycle stages defined by the GHG Protocol Accounting and Reporting Standard, which is in accordance with the ISO 14040:44 standards:

1. Use

2. Manufacturing

3. Material Acquisition / Processing

4. Transport

5. End of Life

Impact and interpretation will be briefly covered under the document's motivation and use cases sections.

There is reason to suspect that nebulous definitions combined with the competitive pressure might produce greenwashing. Greenwashing involves making an unsubstantiated claim to deceive consumers into believing that a vendor's product or solution is environmentally friendly or has a greater positive environmental impact than it does. This document proposes the following initiative to counter these effects.

1.1. The Sustainability Telemetry Standard Specification

As an industry, we need to cooperate and agree on a set of core KPIs that are measured, including the definition of terms, units, and measurement procedures. What is included, and what is not included.

Sustainability metrics require a broad diversity of data sources that need to be combined.

* Static information. Data coming from manufacturing, including reference values on how the assets have been designed if they enable reuse and recycling, and which materials have been used during manufacturing and packaging; normally this information is defined once and it is part of data sheets provided by the vendors.

* Dynamic data. Information measured in real-time or close to real-time from the networking equipment or application. For instance, metrics should consider current inventory and current source and amount of consumed power, as well as what hardware and software features are enabled and used by the specific network equipment.

* Best practices. Recommendations for optimizing the use of the network equipment, throughout its complete lifecycle.

* Local context. Country-specific regulations, corporate policy, and social aspects.

To enable the exchange of sustainability data among all interested parties, deployment considerations that are out of the scope of this document will need to include:

* Data models. The model definition can be implemented in different forms. This document proposes YANG as part of the Specification Data Model. YANG can be used independently of the transport and can be converted into any encoding format supported by the network configuration protocol. YANG models are decoupled from the management protocol layer.

* Sustainability framework. To drive adoption, we propose an open-source aggregation framework for sustainability data. This framework should be seen as a reference architecture for a sustainability monitoring mechanism. While each implementation may be (and will be) different, the basic framework shall remain constant. The framework must account for vendor-specific calculations and enhancements in a plug-in architecture.

YANG data models as part of the Sustainability Telemetry Specification, which will follow this document, have been classified as follows:

* Identification of the assets. Assets include hardware (physical as well as virtual), software, applications, and services. The asset concept is defined in the Asset Lifecycle Management and Operations, Problem Statement (ALMO) [I-D.draft-palmero-ivy-ps-almo] IETF draft.

*Power and Efficiency. To measure power consumption and energy efficiency, common methods, attributes, and units are needed to define metrics. The approach needs to cover the different networking domains, starting with hardware focus, but including software and protocols attributes and metrics.

*Circular Economy attributes. Collecting circularity data (such as materials used, or the embedded emissions footprint) is expensive and difficult because of confidentiality and the non-standardized approach to reporting and exchanging circularity data. The flow of circularity data is typically lost at each step throughout the supply chain, as goods are passed through suppliers, manufacturers, system integrators, distributors, customers, and consumers into reuse and recycling.

*Context metrics. Without understanding the context of the use, none of the metrics listed above will provide much value. The carbon intensity of the power used, for example, is key to assessing the sustainability of a given application. An efficiency number needs to be interpreted differently at peak hours and night. A given usage may be considered less sustainable if someone demonstrates the ability to deliver the same end-user value with a smaller footprint. A system that is transported a shorter distance or using a more sustainable mode of transportation from the factory to the installation site may also be assessed more positively. Or if it has a longer economic life or comes with less single-use packaging.

The model definition can be implemented in different forms. We would like to propose a specific YANG model for the sustainability metrics, which intrinsically allows for a variety of collection protocols. YANG can be used independently of the transport protocol, and lends itself well to be converted into a variety of encoding formats supported by popular network configuration protocols.

The rest of this document is organized as follows. Section 2 establishes the terminology and abbreviations. Section 3 outlines the goals and motivation of Sustainability metrics. Section 4 discusses Use Cases that lay out the groundwork for the Sustainability Telemetry Specification, to address new business needs introduced by the Circular Economy and to avoid excessive climate change.

1.2. Requirements language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in

BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Terminology

Terminology and abbreviations used in this document:

Asset Hardware, software, applications, or services. An asset can be physical or virtual.

Greenwashing Marketing (intentionally or not) an asset as being green (i.e. fitting well into the circular economy) by selectively omitting less green aspects of the asset.

Circular economy An economic paradigm in which the full lifecycle cost of resource use and emissions are included.

Climate change The disruption of ecological processes caused by excessive resource use or emissions.

3. Motivation

Aside from the need for consistency on metrics to be considered as part of the ICT sector, to reduce environmental impact and increase benefit; this document and future work related, aim to support the Digital Product Passport initiative under the European Union's (EU's) Circular Economy Action Plan (CEAP) and the Ecodesign for Sustainable Products Regulation (ESPR). There is not much time for businesses to prepare and for IETF work to influence this development.

The Digital Product Passport (DPP) is key to the EU’s transition to a circular economy and will provide information about assets' environmental sustainability. It aims to improve traceability and transparency along the entire value chain of an asset and to improve the management and sharing of product-related data which are critical to ensuring their sustainable use, prolonged life, and circularity.

There is a need to:

* Track raw materials extraction/production, supporting due diligence efforts

* Enable manufacturers to increase transparency in the value chain, better compliance, increased circularity, and sustainability

* Enabling services related to its remanufacturing, reparability, second-life, and recyclability, enabling sustainable business models.

In the case of upgrading, repairing, repurposing, or remanufacturing a product, it should be clear the responsibility to update the information is transferred to the installer, repairer, or remanufacturer who will be putting the product into service or placing it on the EU market.

The three main target groups of the passport are:

*Public authorities and policymakers: reliable information on compliance of products with EU legislation

*Economic operators (such as recyclers): information on proper dismantling and waste treatment of products; the presence of Substances of Very High Concern (SVHCs) through a link to the SCIP database; etc.

*Consumers: instructions for use, information on repair centers, sorting instructions, and other information as required by existing EU legislation (e.g. CLP regulations), more information about products would be made available to consumers and customers to enable informed choices.

The DPP will help business planners and consumers make informed choices when purchasing assets, and should also help local and public authorities to better perform checks and controls.

4. Next Steps

To enable the exchange of sustainability data among all interested parties at each step of the value supply chain, a technical sustainability framework for how this data is queried, transported, and visualized will be required.

4.1. The Sustainability Framework

To drive quick adoption, we propose to build an open-source aggregation framework for sustainability data. This framework should be seen as a reference architecture for a sustainability monitoring mechanism. The reference implementation will be based on the IETF standards mentioned before. The architecture would supply a few base components, but otherwise, allow vendors or standards bodies to plugin their applications that fit in the general framework. One example of such an application that we would like to propose is a model to calculate the Total Sustainability Cost of Ownership (TSCO) for network solutions based on the Environmental, Social, and Governance (ESG) Materiality Matrix. This matrix model is open to adding any implementation that takes into consideration Sustainability objectives at a point in time, but it also evolves with the needs of the business and the stakeholders. The initial scope proposes to investigate the top four most important ESG

Materiality issues as a base to grow the TCO to a TSCO that matches the Company's priorities and issues.

4.2. Further Development

Items that are not in the scope of this edition of this document, but could be addressed in future revisions, include:

* How to relate Sustainability Telemetry Specification to sustainability Scopes 1, 2, and 3,

* Circular Economy Business models,

* Recommendations,

* Scope 4, i.e. metrics for avoided footprints (sometimes called handprint). For instance, to reduce GHG emissions, automation activities like Zero Touch, or certain technologies like Routed Optical Networking, can replace other higher emitting activities. Another example would be the positive impact arising from video conferencing as opposed to domestic,international travel by airplane.

5. Use Cases

5.1. Use Case I

5.1.1. Scenario 'monitoring power'

An organization is running a large and complex network with many types of devices. By looking at the utility bills, it is clear that the organization is consuming rather more energy per transported bit than many other organizations. Exactly which devices or network functions are at the root of the situation is unclear, however.

The product LCA in this scenario applies to the stage of "Use".

5.1.2. Sustainability Insights Added Value

By providing near-real-time data that is broken down at least to an individual hardware device, and ideally considerably deeper than that, it will be possible to attribute energy and environmental footprint costs to different device types, service types, and individual customers.

If one customer is altering its behavior or load on the network, a monitoring application could detect this quickly. It would also be possible to try several implementations or configurations for a given service and get quick feedback on the operations cost of that change.

5.2. Use Case II

5.2.1. Scenario 'migration'

An organization is running a network with a variety of managed services and applications. Some of the devices are getting old, and have lower energy efficiency than more modern devices. Replacing old devices with new ones might improve efficiency, but has an economical as well as environmental cost. Without specific performance data, it is difficult to make informed decisions about upgrades.

The product LCA stage applies to "Use".

5.2.2. Sustainability Insights Added Value

By providing KPIs for reading sustainability parameters that pertain to actual usage, rather than numbers from data sheets, the accuracy of upgrade decisions is enhanced. Such data can make the case for an upgrade very clear and easy to make, or it may show that it's not a good idea at this time. In both cases improving the sustainability of the operations.

5.3. Use Case III

5.3.1. Scenario 'recycling'

Recycling and reuse are major drivers of the circular economy. Companies must put high efforts in this direction and transparency. This is a qualitative KPI, passed if percentages of recycled and reused goods given the manufacturing options, as well as reports listing how many units have been recycled.

The product LCA applies to the stage of "Material Acquisition / Processing".

5.3.2. Sustainability Insights Added Value

The trend seems to be to report on the percentage of recycled user devices and the eco-design and refurbishment efforts. Sustainability Insights can enable the data sources to report comprehensive reporting of recycling efforts.

5.4. Use Case IV

5.4.1. Scenario 'power optimization'

An organization is running a network with a variety of managed services and applications. The network and application performance is continuously monitored, and there are even some automatic remediation actions that may trigger when certain conditions are detected.

In this scenario, the product LCA applies to the stage of "Use".

5.4.2. Sustainability Insights Added Value

By providing KPIs for sustainability parameters such as power consumption and power efficiency, the monitoring system can access relevant data and perform actions that reduce the power consumption or sustainability footprint of the delivered services.

For example, some overlay redundant links or systems may be powered off at non-pick hours, or enter into a low-power mode. A highly available application may be configured to take more load in the data center with a lower price of energy, lower outside temperatures, or an environmentally superior energy mix.

5.5. Use Case V

5.5.1. Scenario 'sustainability cost'

IT solutions are currently analyzed from two main perspectives: technological and economical. When looking at environmental, social, and corporate governance (ESG) impact topics, sustainability metrics in the context of digital transformation, deliver insights into opportunities and risks that emerge from a rapidly growing stakeholder demand for sustainable, digitally advanced products and services.

The product LCA applies to all stages under its lifecycle.

5.5.2. Sustainability Insights Added Value

From an application point of view, this use case proposes to include Sustainability factors in the Total Cost of Ownership (TCO) calculation, where there is a need to add Environmental, Social, and Governmental Key Performance Indicators (KPIs) to the analysis. However, adding Sustainability metrics comes with challenges and trades-off. Future work considers a model to calculate the Total Sustainability Cost of Ownership (TSCO) for network solutions based on the ESG Materiality Matrix. This model is open to adding any implementation that takes into consideration Sustainability objectives at a point in time, but it also evolves with the needs of the business and the stakeholders. The initial scope proposes to investigate the top four most important ESG Materiality issues as a base to grow the TCO to a TSCO that matches the Company's priorities and issues.

Future work might include use cases that will cover "Manufacturing", "Transport" and "End of Life" examples.

5.6. Use Case VI

5.6.1. Scenario ‘switch off’

WIFI is deployed in any famous stadiums around the world. It is common for such networks to rely on several thousands of Access Points (APs).

Such networks are very dense and designed to separate finely fans connections from business operations (ticketing, ...).

Such WIFI network activity varies in time and follow a well-known calendaring (but not as trivial as the match calendar). It is obvious that the bigger part of a stadium WIFI network footprint is most of the time unused at all.

Current WIFI management tools are not designed to stop and restart the APs automatically following a schedule. In 2022 Orange and Cisco implemented practical actions to lower the power consumption of the WIFI APs of the Orange velodrome of Marseille. The experimentation was able to save 20% of the APs power consumption without modifying the infrastructure. The experimentation shown that the current design of network operation tools need to be updated to save up to 50%.

Stadium and arenas WIFI network are made of a very limited number of clusters. There are WIFI networks similar in size which are by far more constraint in term of calendaring and capillarity. In France, banks have thousands of branches. See Number of bank branches in France.

NB: APs are not per designed build to support numerous cold restarts. This may impacts TSCO

5.6.2. Sustainability Insights Added Value

Being able to stop and restart WIFI APs with the right time, space and service granularity.

From an operation point of view, this use case proposes to save power consumption during periods the APs are not in-used.

6. Architecture Framework

This section proposes a reference architecture for Sustainability Insights framework.

The following picture shows an example of how a framework like this could look like in a small data center use case.

Each component has a type (top line, in capitals), a name (lines below), and an id for reference (number in the lower right).

```
                      +-----------------+
                      | USER INTERFACE  |
                      |    Dashboard    |
                      |                 |
                      +--------------11-+
                               |
                      +-----------------+
                      |    PROCESSOR    |
                      | Recommendation  |
                      |     Engine      |
                      +--------------21-+
                               |
                      +-----------------+
                      |   AGGREGATOR    |
                      |   Data Center   |
                      +--------------31-+
                               |
       +---------------+-------+-------+--------------+
       |               |               |              |
+------------+  +------------+  +------------+  +------------+
| PROCESSOR  |  | AGGREGATOR |  | AGGREGATOR |  | AGGREGATOR |
| Normalizer |  |  Network   |  |  Storage   |  |  Compute   |
+---------41-+  +---------42-+  +---------43-+  +---------44-+
       |           |                   |\             |\
+------------+     |     +------+------------+  +------------+------+
| COLLECTOR  |     |     | YANG | COLLECTOR  |  | COLLECTOR  | YANG |
|  Cooling   |     |     +---52-+ Storage 1  |  | Compute 1  +---55-+
+---------51-+     |            +---------53-+  +---------54-+
       |           |             \ Storage 2  \  \ Compute 2  \
+------------+     |              +------------+  +------------+
|  PROVIDER  |     |               \ Storage N  \  \ Compute N  \
|Utility Bill|     |                +------------+  +------------+
+---------61-+     |
                   +--------------+
                   |              |
            +------------+  +------------+
            | COLLECTOR  |  | PROCESSOR  |
            |  Router 1  |  | Normalizer |
            +---------71-+  +---------72-+
                   |              |
            +------------+  +------------+
            |  PROVIDER  |  | COLLECTOR  |
            |  Router 1  |  | Firewall 1 |
            +---------81-+  +---------82-+
                                  |
                            +------------+
                            |  PROVIDER  |
                            | Firewall 1 |
                            +---------92-+
```

Figure 1: Example component diagram of a Sustainability Insights deployment.

In the above diagram, each component may be procured from a commercial provider, obtained as open source, or developed from scratch by the deploying organization. The reference design project would contain a base collection of components of each type. Typical controllers would implement multiple, possibly all, controller functions in a single system, in which case each box above translates to a piece of configuration.

The key aspect of this architecture is the interfaces between the components. These interfaces are specified in YANG. The YANG interface may then be mapped to a variety of wire protocols.

6.1. User Interface

The topmost component (11) in the architecture diagram is a User Interface component. It would display both time-series footprint data, aggregated footprint data and results from analysis of the data.

6.2. Processor

Processor components (21, 41, 72) take an incoming data flow and transforms it somehow, and possibly augments it with a flow of derived information. The purpose of the transformation could be to convert between different units of measurement, correct for known errors in in the input data, or fill in approximate values where there are holes in the input data.

6.3. Aggregator

Aggregator components (31, 42, 43, 44) take multiple incoming data flows and combine them, typically by adding them together, taking possible differences in cadence in the input data flows into account.

Aggregators wouldn't normally store the aggregated time series data, and delivers data to a client on client request.

6.4. Collector

Collector components (51, 53, 54, 71, 82) collect time series data flows (by polling or subscriptions) and ensure the input data is stored in a way so that this component can deliver the data in a convenient and timely manner to other components in the framework.

Two of the Collectors (53, 54) have YANG module attached. This is because the systems they are connected to do not have YANG models of their own. In such cases, it is the responsibility of the Collector to provide a YANG description of the data being pulled from the underlaying system(s).

6.5. Provider

A Provider component (61, 81, 92) delivers a snapshot reading interface or subscription service of some quantities. Collectors may poll or subscribe to some of the quantities provided by Providers at desired intervals. Collectors may collect streams of informations from other sources than Providers.

6.6. YANG

A YANG module (52, 55) describing the pulled data is required for all systems that do not provide their own YANG description of their telemetry data. This YANG module reflects the structure and naming of the data that the collector ensure is flowing into the collection system.

7. Deployment Considerations

Sustainability Data Models defines the data schemas for Sustainability Insights data. Sustainability Insights Data Models are based on YANG. YANG data models can be used independently of the transport protocols and can be converted into any encoding format supported by the network configuration protocol. YANG is protocol independent.

To enable the exchange of Sustainability Insights data among all interested parties, deployment considerations that are out of the scope of this document will need to include:

* The data model definition

* The data structure to describe all metrics and quantify relevant data consistently, i.e. specific formats like XML or JSON encoded messages would be deemed valid or invalid based on Sustainability Insights models.

* The process to share and collect Sustainability Insights data across the consumers consistently, including the transport mechanism. The Sustainability Insights YANG models can be used with network management protocols such as NETCONF [RFC6241], RESTCONF [RFC8040], streaming telemetry, etc. OpenAPI specifications might also help to consume Sustainability Insights metrics.

* How the configuration of assets to implement Sustainability Insights telemetry should be done.

It will be important to consider where, when, and how often the data will need to be collected. As per the specification of the data, data might need to be collected from different data sources: network devices, and different databases where manufacturing information is stored and maintained. Ideally all this information can be extracted via a well-defined API. The frequency to collect the data will also vary, for instance, comparing manufacturing data with runtime data. For example, it might be a good practice to collect inventory data once per day, while “environmental” data might need to be updated hourly or even more frequently. It will also be important to consider the platform from where data might be collected, and the need to properly correlate all the information.

8. Security Considerations

The security considerations mentioned in section 17 of [RFC7950] apply.

Sustainability Insights brings several security and privacy implications because of the various components and attributes of the information model. For example, each functional component can be tampered with to give manipulated data. Sustainability Insights when used alone or with other relevant data, can identify an individual, revealing Personal Identifiable Information (PII). Misconfigurations can lead to data being accessed by unauthorized entities.

Methods exist to secure the communication of management information. The transport entity of the functional model MUST implement methods for secure transport. This document also contains an Information model and Data-Model in which none of the objects defined are writable. If the objects are deemed sensitive in a particular environment, access to them MUST be restricted using appropriately configured security and access control rights. The information model contains several optional elements which can be enabled or disabled for the sake of privacy and security. Proper authentication and audit trail MUST be included for all the users/processes that access Sustainability Insights Telemetry Data.

9. References

9.1. Normative References

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Change log

RFC Editor Note: This section is to be removed during the final publication of the document.

version 02

* includes explanation and new diagram for the architecture framework, and Use Case VI.

version 01

* includes architecture framework section.

version 00

* Initial version of the draft.

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Authors' Addresses

Per Andersson
Cisco Systems

Email: perander@cisco.com

Jan Lindblad
Cisco Systems

Email: jlindbla@cisco.com

Snezana Mitrovic
Cisco Systems

Email: snmitrov@cisco.com

Marisol Palmero
Cisco Systems

Email: mpalmero@cisco.com

Esther Roure
Cisco Systems

Email: erourevi@cisco.com

Gonzalo Salgueiro
Cisco Systems

Email: gsalguei@cisco.com

Emile Stephan
Orange

Email: emile.stephan@orange.com