Instrumentality, Perception and Listening in Crossadaptive Performance

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Abstract

Crossadaptive processing describes situations where one performer's output effects the audio processing of another, thus imposing direct modulation on the sound of another performer's instrument. This is done by analysis of the acoustic signal, extracting expressive features and creating modulation vectors that can be mapped to audio processing parameters. Crossadaptive performance can be situated between the performance practices of the audio processing musician, augmented (acoustic) instruments, live algorithms, group improvisation and interconnected musical networks. The addition of crossadaptive processing to these musical practices brings up questions of agency and instrumentality. Performance with crossadaptive techniques produces complex behaviours that are difficult to describe by the performer or the listener. This paper covers issues of transparency & technical language, instrument and ensemble learning. For the performer a shared ensemble identity may emerge. And for the listener we discuss the role of intention and emergent musical behaviour.

Keywords
Feature extraction
Modulation
Live processing
Crossadaptive performance
Instrumentality
Agency
Improvisation

Introduction

The current paper explores issues encountered in the project "Cross-adaptive audio processing as musical intervention". Digital audio analysis methods are used to let features of one sound modulate the electronic processing of another, allowing one performer's musical expression on her instrument to influence quite radical changes to another performer's sound. This action deeply intervenes with the performance environment for the other musician. The continuous timbral modulations imposed on one's own instrumental sound enables new forms of creative interplay, and at the same time inhibits some learned and habituary modes of performance. Listening, anticipation, preconception, and thus motivation to exert said modulations are closely linked to expectation and familiarity. The project method is thus based on iterative practical experimentation done in studio sessions. Sessions are documented by multitrack audio and video recording, and reflections supported by short personal video interviews with the participants. Documentation is an integral part of the reflection process in the research project. The documentation is also made publicly available in a research blog.[1] Development of processing tools and composition of interaction mappings are refined on each iteration, and different performative strategies explored.

1.Crossadaptive processing and signal interaction

Interaction between two or more audio signals has been used for creative sound design purposes in a number of contexts. Stockhausen's use of *Ring modulation*, Laurie Anderson's use of *Vocoder,* and the *Auto-wah* effect on Stevie Wonder's clavinet are examples of adaptive and crossadaptive treatments. Similarly, the pumping effects of *sidechain compression* is ubiquitous in pop music of the last 20 years, an example is Eric Prydz' *Call On Me* from 2004. In the same period, we have also seen extensive research into adaptive (e.g. Verfaille, Zolzer and Arfib 2006) and intelligent (e.g. Reiss 2011)

effects for music production, and more recently these techniques have been put to use for live performance (e.g. Fasciani 2014, Brandtsegg 2015). The activities in this field use signal analysis to extract control vectors for use of parametric control of effects processing. Many of the feature extraction methods come from the field of music information retrieval, but the utilization of these features to form control signals for processing lies within crossadaptive processing. *Crossadaptive performance* relates to the use of crossadaptive processing for live performance, where the musicians are enabled to modulate the sound of each other's instruments. Assuming that a musician relates intimately to the sound of her instrument, allowing another musician to change the sound on the fly will enable radically new forms of interaction, between performer and instrument as well as between performers.

In addition to the feature extraction and modulator mapping described above, our exploration of crossadaptive performance has also included processes of more direct signal interaction between two sources, for example with convolution, where we have adapted the technique for live interaction by devising a method of continuous update of the filter (see Brandtsegg, Saue and Lazzarini 2018). *Convolution* has some interesting implications for signal interaction, as the temporal characteristics as well as the spectral profile of one signal are imposed on the other.

2.Situating crossadaptive processing in other performance practices

Crossadaptive performance can be situated between the performance practices of the audio processing musician, augmented (acoustic) instruments, interactive music machines or live algorithms, group improvisation and interconnected musical networks, but also has distinct differences from these practices. An audio processing musician's role is to process the sound of another musician (or multiple musicians). Most often the instrument pro-

1 http://crossadaptive.hf.ntnu.no/. In the footnotes in this paper linking to particular entries of the blog we use shortlinks.
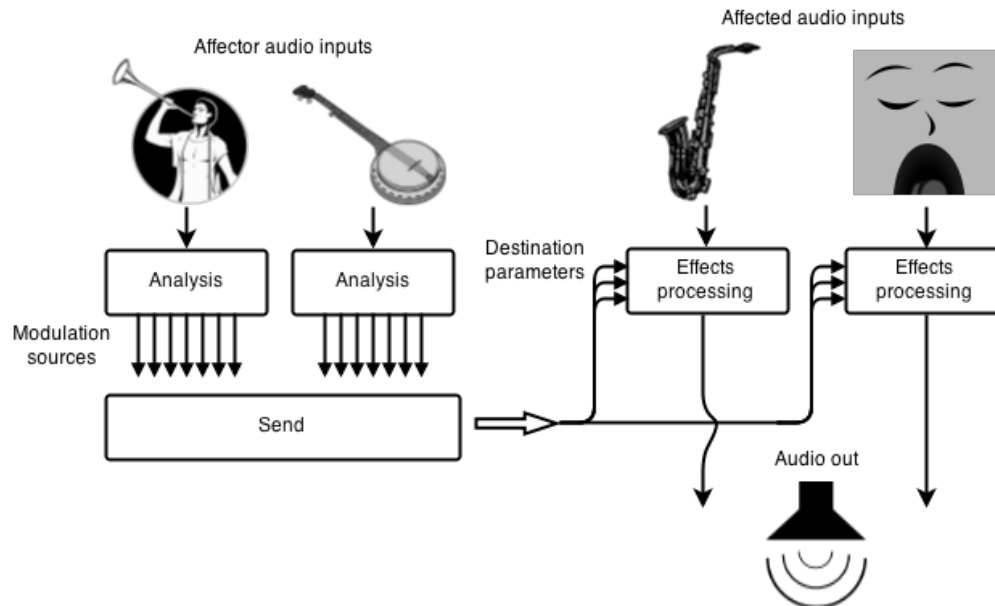
Figure 1. Analysis of expressive features generates modulator signals (Brandtsegg 2015)

cessed is an acoustic instrument. The artists Dafna Naphtali and Joel Ryan are examples. They have developed a set of realtime audio processing units and control interfaces for live performance. During the performance they use these tools as they make decisions on which to use while responding to the acoustic and the combined sound they create. The decisions they make are as much based on experience gained through building their tools as performing them in different situations with different kinds of musicians (Naphtali 2016). While playing, a dialogue unfolds between the musician whose sound is processed (who will adapt his playing based on the effects on his sound) and the processing musician.

Various musicians have augmented their acoustic instrument to process the sound. The acoustic sound is captured, analysed and processed during performance, controlled by sensors mounted onto the instrument. Examples of augmented instruments are Gibson's modified cello (Andersen and Gibson 2017) and Leeuw's electrumpet (Leeuw 2009). The latter also makes use of auto-adaptive processing of the sound.

Interactive music machines or *live algorithms* usually consist of a set of analysis methods to determine what a musician is playing and some sort of system to create a sonic response to what the musician is playing. Besides live processing, often these algorithms operate on a longer timescale, giving musical phrases back in response to phrases that were played by the human performer. A live algorithm can: 1) collaborate actively with human performers in real-time performance without a human operator; 2) make apt and creative contributions to the musical dimensions of sound, time and structure; and 3) contain a parametric representation of the aural environment which changes to reflect interaction between machine and environment (Lewis 2007).

Group improvisation is a practice where a group of musicians plays together to improvise together: that is, they do not have a preconceived score that they play, rather each musician draws on their own skill in playing their instrument and by playing together and listening to each other, a joint sonic experience is created. Often there is a notion that the sound created together is more than the sum of its parts and

by improvising together the musicians inspire and challenge each other allowing each to find new ways of playing their instruments. Weinberg (2005) discusses interconnected musical networks. His examples involve completely electronic or digital networks, but the crossadaptive performance setup also fits well into his description, and the theoretical framework he presents can be used to further analyse and understand crossadaptive performance situations.

With crossadaptive processing the sound of an acoustic instrument is augmented through processing, similar to the audio processing musician in that one musician is processing the sound of another musician. However, there is a distinct difference in that the control over this processing is indirect: it depends on the acoustic features or musical qualities of the sound another acoustic musician is playing, rather than explicit control using sensors and controllers. The setups for crossadaptive processing are similar to live algorithms in that the algorithms are decided upon and fixed before the performance. The choices for which analysis features to use to control certain processing parameters, and the choices for which processing algorithms to use and which parameters to control are made before the musicians start to play. Of course, these design choices can be and often are informed by previous playing sessions. Also there may be a choice to play with different sets of crossadaptive entanglements, thereby dividing the live performance into different sections. In the connections that are made, usually the effect is taking place *in the moment,* that is the algorithms do not perform by themselves on higher level time structures of the music.

A crossadaptive performance is a special case of a group improvisation with the added entanglement of the instruments through the crossadaptive connections that are made between the acoustic instruments. For the performer being modulated then, there is a filter into which one's expression on the instrument must pass. Cobussen (2017) in his theory of *Field of Musical Improvisation* understands musical improv-

isation as a nonlinear, dynamic and complex system in which various actants are at work: not only the musicians, but also "space, acoustics, instruments, audience, technicians, musical and socio-cultural backgrounds, technology, and the like all play a significant role". He also stresses the singularity: "each improvisation thus yields a different network of actants and interactions, a unique configuration or assembly." When we look at the performances that were done during this project, this insight helps us to understand the crossadaptive interaction.

3.Notions of instrumentality

Looking closer at what happens during a crossadaptive performance, questions of agency of the musician and the musical instrument arise. In the discussions following the crossadaptive playing sessions, one musician remarked: *"It is like giving away some part of what you've played, and it must be capable of being transformed out of your own control"*[2]. This remark hints that the single musician is giving some of their sound to another agency within the performing context. In the discussion around the *live convolver*[3] that was developed the musicians noted that they could be either in control of the timing of the musical events or of the sonic texture.[4] Notably also different musicians found one form of control more comfortable than another, presumably based on different modes of music making (e.g. more biased towards the timbral image, the temporal phrasing, the gestural energy flow, etc.). Other concepts that arose from the discussion of the playing within a crossadaptive setting were the notion of *control intimacy*: how close the physical gesture is to the sound that is created and *reactive inertia*:[5] how fast the player can change the sound she is playing.

A pianist remarked "It felt like there was a 3rd musician present."[6] And this points to the notion of the crossadaptive processing having its own agency, similar to Peters (2016) observation when playing in a physically interconnected assemblage of instruments: "We understood that we were dealing with an unfamiliar other,

2 http://wp.me/p7UOyo-ci
3 In the live convolver the sound of one musician is captured in a buffer. This buffer is then used as an 'impulse response' with which the sound of the other musician is convolved. For a more in-depth description, see (Brandt-segg, Saue and Lazzarini 2018).

4 http://wp.me/p7UOyo-e0
5 Described in blog post http://wp.me/p7UOyo-e0#reactive
6 http://wp.me/p7UOyo-cE

and we kept the shared imaginative connection we had immediately made between the natural agencies (. . .) and that voice's agency intact".

Alperson (2008) argues that "ontologically, musical instruments need to be understood as musically, conceptually, and culturally situated" and as "an amalgam of material object, the performer's body, and bodily dispositions as habituated by the developments of various musically related skills" (including not only those of performers but also of instrument builders, composers and the audience). He argues that "musical instruments must be understood as instrumentalities in the context of human affairs". He writes "what the performer does is perform a work with an instrument that is at once both *recalcitrant* – insofar that it must be 'mastered' so that the instrument can be utilized in the service of the production of musical works – and *intimate* – insofar as musical instruments are inevitably connected with the bodies and bodily actions of performers" (our emphasis). He recognises the performance as a 'work-in-performance' that is "doubly bound in consciousness" in that it can be appreciated aesthetically in terms of its instrumental accomplishment: appreciating both "the performance *of* the work, as the performance *in* the work." (our emphasis).

Peters (2016) extends Alperson's concept with the notion of *shared instrumentality*, which can vary over time. He uses the term *distributed instrumentality* for the idea that many instruments join up to form a single instrument (e.g. in an orchestra) and then describes how over the course of a performance instrumentality can *shift* between its *individual* (monadic) and *distributed* (shared) forms as *individual* sonic territories are negotiated with the *interdependence* of decision-making and the creation of *shared* gestures. In the example of his assemblage performance with his ensemble he describes how the environmental agency (that comes out of the physical interconnection between the instruments the performers are playing) can enter and contribute its intrumen-

tality,"the interconnectedness of the instruments creates a new instrument". The listener to the ensemble can then at the same time appreciate the "*technical* accomplishment and the virtuosity; she can also appreciate the performers' interpersonal accomplishment and virtuosity" (his emphasis).

In view of Alperson's discussion (2008), the instrumentality of crossadaptive processing encompasses both the creation and building of the crossadaptive connections between the instruments before they are performed, and the performance with these connections. The instrumentality of the performers that they can build up then encompasses (similar to the 2nd order instrumental skills of Marques Lopes, Hoelzl and De Campo (2016)):

• familiarity/knowledge/implementations of feature extraction for their (acoustic) instrument,
• familiarity/knowledge/implementations of processing for their (acoustic) instrument,
• experience in playing in different constellations (with different musicians playing different instruments),
• and in the moment of performing in a particular setup: the accomplishments within that performance.

Similar to Peters's (2016) physical interconnectedness of instruments, in the crossadaptive setting (where the interconnections are made by algorithms), the musician has to balance her own individual sonic territory (the direct sound of her instrument) with the shared sonic territory (emerging out of the processing of her instrument's sound controlled by the other musicians sound, and the processing of the other musicians' sound based on analysis of her own direct sound). Meanwhile the other musicians are also navigating between this individual and shared territory. Depending on how the interconnections have been set up, it may be that there is almost no possibility to create an individual gesture as it is always (also) a shared gesture.

Equivalent to Peters's (2016) ensemble setup, the crossadaptive interconnectedness of instruments can be seen as an environmental agency, although we can also argue, especially in the case of multiple musicians being inter-connected in different pairwise ways with other musicians (e.g. between saxophone and guitar, guitar and percussion, and percussion and saxophone.) that a multiple of such agencies emerge out of the performing together. Lewis (2018) writes "Through improvisation, with and without machines, and within or outside the purview of the arts, we learn to celebrate our vulnerability, add part of a continuous transfor-mation of both Other and Self." In improvisation with crossadaptive processing, this vulnerabil-ity is mutual and interdependent.

4.Discourse and communication — How we talk

In analysing how we perceive and talk about performance, there is a tension between the viewpoint of the performer and the listener, and also between the experiential (phenomenologi-cal) and the technical approach. On the technical level, the performer has an understanding of her own acoustic instrument, the methods used for feature extraction on the sound of her instru-ment, and the effects this will have in modulating the instrument sound of other performers in the ensemble. Also she knows what features from the other instruments will control the processing of her own sound. During the performance, the performer has an embodied experience, where she has an active influence on the process. At this moment there may be a tension with the desire to forget about the technical implemen-tation while performing. Borgo (2005) describes this desire in Evan Parker's music as a shift from left-brain to right-brain activity and "although (Parker) had worked diligently to establish these extended techniques, he believes the best parts of his playing to be beyond his conscious control and his rational ability to understand." Thus being able to forget about the techniques may improve the experience of performing. However,

to be able to adjust and improve the experience, an understanding needs to be gained on what aspects of the technical implementation worked and which did not, so they can be adjusted.

During the performance the listener has an experience of listening to the music, the music affecting his mind and body in a non-analytical, non-verbalised way – the experience of being there in the moment in the same space with the performers. At the same time, the listener is curious about what is happening and may attempt to analyse what is going on: Who is creating which sound, who is doing what? What are the interactions between performers? The socio-cultural, musical and technical back-ground of the listener as well as the information provided by the performers and the event organ-isers will affect this analysis and how the listener can subsequently verbalise her understanding of what happened during the performance. For the performer and listener to discuss the performance, awareness of these different levels of understanding and making translations between these levels is important: a listener may have observed important interactions between the musicians, but verbalise these in a way that is not directly understandable to the performer. And vice versa.

5.The crossadaptive instrument

Musicians generally learn (in any style or genre) through a variable mix of two approaches. On the one hand small increment demonstrations[7] – more atomistic, from which larger ideas are built up – and, on the other, the practice of learning through creative play – more holistic, which may be broken into smaller chunks on reflection.[8] In crossadaptive performance the challenge is that there must be at least two mutually interactive performers who must learn their instrument together. A specific aim – a desired change or end – may not be feasible; indeed a rational choice may only be possible in the most general terms.[9] We might wish to have a binary 'we do' or 'we do not' know the outcome of an experiment. In practice, however, while learning

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7 For example Trond Engum's documented sessions are excellent examples of small increment learning.
8 For example the session at UCSD Studio A, June 2017, complex mappings were used with a more holistic explora-tive approach.
9 NTNU meeting discussion June 2016.

a new system such as this, performers become aware of a range of more general possibilities. It may be we need to shift from control intimacy to much more *fuzzy causality* – this type of action will have this *range* of possible results. The mapping of action to result is no longer simple.

The recursive interaction of crossadaptive processing creates a potentially unstable mapping. There is (probably) no longer a direct linear causal relationship to any result. While we might expect the possibility of a kind of 'chaotic anarchy', many of the learning and practice sessions[10] show that rehearsal acts as a 'control filter'. A criteria that emerges in discussion and observation appears to focus on making 'ecological' sense (or not) of the possible results. This strongly suggests that the mapping need not be conceptualized in detail but that metaphoric and more general descriptors emerge as more useful. Contributors to one discussion likened this to learning to balance on a high wire or to ride a bicycle. So we see developing an 'immanent' or 'emergent' description of the results – holistic and not detailed. Our language makes a transition from a local to a global description. This shifts issues of control or influence over what is performable. A holistic approach allows other modes of control: ". . . not to intellectually focus on controlling specific dimensions but to allow the adaptive process to naturally follow whatever happens to the music"[11]

6.Perception, imagination, intentionality, emergent qualities

The question of sound monitoring in such a complex performance situation needs to be addressed and this effects how we can "play by ear". Several of the performers on the crossadaptive project also commented on this. For example Kyle Motl and Steven Leffue in session reflections.[12] This also raises the question of "is it important enough to the performer to effect this change in another musician's sound, so that she will switch from what she was otherwise about to play?" As open an issue as this may be, one can imagine it has to do with the degree of

preconception. If the musician can preconceive the effect, then there might be an urgency and a will to do what is required to effectuate that change. Then again, we see some particular areas of conflict, where the desire to play (or not play) something might conflict with the desire to control some parameter. The roles of "playing as a controller" or "playing as an independent instrument" can be used to indicate some of this conflict.

So is this music interesting in itself as music or is it interesting merely by means of its production methods? Indeed some of the musically interesting features of the music are connected to the modulation interaction patterns. One could object that this makes it merely intellectually or technically interesting. Then again, just as a random example, say, when Thelonius Monk attempts to play microtonally by means of using clusters of semitones, there is an interesting musical negotiation between intent and instrument. The manner in which the characteristics of the instrument are explored to express the initial creative impulse makes this music have an additional layer of fascination available.

Finally and most importantly there is the issue of intentionality – not a new discussion but very important here. The traditional form of the question might be 'Does what the creator intends matter?'. But we have confused this issue here – above, we suggested that with crossadaptive processing scenarios we may have only very vague (fuzzy) notions of what might happen next – so our intentions likewise cannot be specified exactly a *priori*. This may have no bearing on whether this makes the music 'good' or 'better'. 'Did you hear what was happening?' could be asked by a listener. What does it mean: 'To hear a process' – this is not the aim (we suggest). Too often this implies a kind of technological listening – do you hear the technical processes? Do you 'decode' how these operate? Let us ask instead 'Do you hear what is happening *musically*'? For that we hear *the results of the process* – the sense of an *emergent* quality that comes about through a procedure the listener may *not*

10 For example the seminar of 16 December 2016.
11 http://wp.me/p7UOyo- e0
12 http://wp.me/p7UOyo- fw#playbyear

be able to identify or describe. Thus, as we have already remarked, the listener may have no need of knowing, or any means to know, the details of a crossadaptive interaction. Other overall characteristics may emerge – in performativity: senses of play, exploration, interaction, or in the musical material: timbral, textural. The sense of fluid flow in its many manifestations is one such common emergent property.

So we have an interesting additional duality here – can the performer hear the emergent property to which they contribute? Well, maybe. There are some issues here that are technical, philosophical and ethical at once. Treating the individual performer as a 'cog in a machine' – only aware of the immediate cogs surrounding – is a continuation of a long tradition within western art music. If, however, we wish to empower the performer to take performative decisions (however fuzzy) then this question becomes immediately more complex.

7. Evaluation and reflection on potential

As we have seen in practical experiments, the issue that one performer's actions modifies another performer's sound has some profound musical consequences and implications. Since the performer cannot necessarily expect to follow up her statements, the opportunity to build form on various levels has been punctured. Then, with these clearly limiting factors, what makes it worthwhile? The musical action of crossadaptive processing has some potentially attractive features that we could say belong to the compositional: allowing one character/gesture/motif to reappear somewhere else and thus create connections in the compositional whole. With crossadaptive performance, these connections would most often be synchronous. Something changes in a particular manner in one part of the sound world, while something else changes in perfect synchrony somewhere else. Still, it is not simple mimesis, the connection will most often be blurred because it also depends on a complex set of factors.

The potential for co-creation and interconnected timbral modulation gives birth to a new set of affordances. Overcoming the flip side elements may well be a question of mastering the new, collective instrument. One could argue that we, after more than two years of exploration, should have gotten some sort of control over this. Then again, part of these two years have been spent identifying (and getting to know intimately by performance) the problems, and also actively seeking to discover potential unknown problems by working with diverse groups of performers. Perhaps the mastering of the collective instrumentality, and the environmental agency is one of the biggest challenges.

One could also argue that the instrument design to a very high degree determines the musical potential and the modes of exploration. In this we include the selection of effects to apply to process the sound, the features to extract, and how exactly to map them. The mapping from features to control parameters can be characterized along a dimension from simple to complex, direct or indirect. A simple mapping can be easy to understand for performers and listener with a perceptually direct connection between action and modulation. More complex mappings can enable intricate relationships and rich environments. Some parts of the mapping may only be enabled under certain conditions. Such complexity can enable the construction of a rich potential for intricate expression or it can result in obfuscation and lack of control intimacy. If this seems exaggerated or contrived, in terms of the number of active control parameters and their mappings, think of the situation with a traditional acoustic instrument like the violin or the human voice. There are literally dozens of control parameters of varying influence on the sound, and some of them are only active on the condition of the activation of other control parameters. The most radical aspect of crossadaptive modulation is thus that the conditions of activation may lie in the hands of another performer.

Control intimacy as coined by Moore (1988) allows an open interpretation, but is commonly used to signify an instrument's facilitation to minimize the distance between the performer's intent and the musical outcome. In such an interpretation, crossadaptive methods will in many cases lessen the control intimacy. However, we might argue that the control intimacy of cross adaptive performance is greater than elsewhere, because it is symbiotic and dependant on conditions. The actions of the other performer enables certain nuances within my expression. Control intimacy is not a static feature of the instrument but is dependent on skill, and in this context also on interaction with the other performer.

8.Conclusions and future directions

We have looked at the relatively recent practice of crossadaptive performance, and situated it in the light of other electroacoustic and improvisational performance practices of the last few decades. As part of the investigation, we have also looked at the instrumental agency and the shared instrumentality that naturally arise in the context of crossadaptivity. To discuss the process we found that we needed to balance the phenomenological (holistic) and the technical (atomistic) approaches, as well as consider the viewpoints of the performer and the listener. This somewhat phenomenological approach is also suffused by an evaluation and a reflection on the yet-to-be-tapped source of intimately tuned musical expression enabled by these techniques.

After two years of intense exploration, it seems the field has more the character of an explosion of potential directions than a condensation and stabilization. It is clear that the crossadaptive mode of performance requires specialized skill and that further experimentation with a select few performers may be fruitful. Simultaneously, we see a huge variety of approaches, even

within our relatively small group. Perhaps 50 performers have been in direct contact with these techniques within our research project, and with the variety seen here, one could expect other groups of performers to come up with wildly differing perspectives and vantage points. As such, one important part of future work is to make the work methods more easily accessible for performers and researchers outside of our group. We also see that others are already picking up alternate modes of utilization.[13] Other use cases might involve expressive control of technology in a wider context, say, like voice control of devices and environments. Crossadaptive techniques involves methods of expressive analysis that might enable nonverbal emotive control of such responsive environments. These are but a few of the yet unexplored directions.

13 For example in the project "Goodbye intuition" currently being conducted at the Norwegian Academy of Music.

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